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CANADA COMMUNICABLE DISEASE REPORT

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Photo is a scanning electron microscopic (SEM) image depicting a red-colored *Salmonella* sp. bacteria, invading a mustard-colored, immune cell. Produced by the National Institute of Allergy and Infectious Diseases (NIAID). https://phil.cdc.gov/phil/home.asp.

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ENTERIC DISEASE OUTBREAKS

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RESEARCH

Analysis of enteric disease outbreak metrics, British Columbia Centre for Disease Control, 2005–2014

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Abstract

Background: For enteric disease outbreaks, effective control depends on timely intervention. Routine collection of metrics related to outbreak identification, investigation and control can help evaluate and improve interventions and inform further analyses and modelling of intervention effectiveness.

Objective: To analyze data from enteric disease outbreaks in British Columbia, generate outbreak metrics and assess their use in evaluating the impact of outbreak interventions.

Methods: This descriptive study analyzed data from 57 provincial and national enteric disease outbreak investigations involving the British Columbia Centre for Disease Control from 2005 to 2014. Data were extracted from internal files and the Canadian Network for Public Health Intelligence. Outbreak metrics analyzed included days to initiate investigation, days to intervention, number and type of interventions, duration of investigation, duration of outbreak and the total number of cases.

Results: The median time to initiate an outbreak investigation was 36 days and the median duration of investigations was 39 days. The median duration of outbreaks was 40 days and the median time to intervene was 10 days. Identification of the source was associated with use of one or more interventions ($P<0.0001$). The duration of outbreaks was correlated with the number of days to initiate an investigation ($r_s=0.72$, $P<0.0001$) and number of days to intervene ($r_s=0.51$, $P=0.025$).

Conclusion: Identification and analysis of outbreak metrics establishes benchmarks that can be compared to other jurisdictions. This may support continuous quality improvement and enhance understanding of the impact of public health activities. Date information for public health actions is essential for evaluating the timing and effectiveness of outbreak interventions.

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Introduction

The objective of an outbreak investigation is to identify the source and implement timely and appropriate interventions to control the outbreak (1). The timeliness of control measures often depends on how quickly an outbreak is first identified and solved. If implementation of control measures is delayed, they may have little impact. Hence, it is of value to track metrics (indicators that can be compared over time and to other jurisdictions) related to the timeliness of outbreak identification, investigation and control. Historical outbreak data can be used to create these measures.

Routine collection and analysis of outbreak metrics can inform quality improvement activities. In the United States of America, the Foodborne Diseases Centers for Outbreak Response Enhancement (FoodCORE) program collects standardized metrics on foodborne disease outbreaks to improve outbreak response (2). Outbreak data have also been used to assess the impact of interventions. Seto et al. (2007) used data from a multistate outbreak of *Escherichia coli* O157:H7 in the United States to model control strategies and found that reducing secondary transmission by 1–25% could prevent 2–3% of secondary cases and 5–11% of infected and symptomatic individuals (3). Chen et al. (2014) used data from a waterborne shigellosis outbreak at a school in China to examine the effect and optimal combination of five interventions on the attack rate and outbreak duration (4). Despite the usefulness of outbreak metrics, such measures are seldom evaluated or reported (5).

The British Columbia Centre for Disease Control (BCCDC) is responsible for coordinating investigations of enteric disease outbreaks that affect more than one region in British Columbia (BC). It also assists in investigating outbreaks that affect a single

BC region or the province and multiple Canadian provinces. This involves identifying outbreaks, developing case definitions and outbreak questionnaires, analyzing the epidemiologic data collected, implementing epidemiologic studies, providing recommendations on control measures and communicating with the public (6). Information resulting from these activities can be used to improve public health interventions and their impact. Efforts should be made to develop and measure indicators that are useful to public health partners and the general public.

In this article, we present the first phase of a study to assess the impact of interventions on the duration and size of enteric disease outbreaks. The objective of this study was to analyze British Columbia enteric disease outbreak data, generate outbreak metrics and assess their use in evaluating the impact of outbreak interventions.

Methods

Data from provincial and national enteric disease outbreak investigations that involved the BCCDC were included for analysis. Data from 2008 to 2014 were extracted from the Canadian Network for Public Health Intelligence (CNPHI) on July 24, 2015. Data on outbreaks involving the BCCDC from 2005 to 2008 were extracted from internal files at the BCCDC, including outbreak summaries and investigation meeting minutes.

Outbreak inclusion criteria

We defined BCCDC involvement based on two criteria: at least one of the enteric illness cases was in British Columbia and BCCDC participated in the outbreak investigation through meetings, by providing epidemiologic support and/or by coordinating the investigation of the outbreak. Enteric outbreaks were included if they met the definition of community outbreak (≥ 2 unrelated cases with similar illness that are epidemiologically linked), institution outbreak (≥ 3 cases with similar illness that are epidemiologically linked) or a single case of botulism (based on the Public Health Agency of Canada's *Outbreak Summaries User Manual* version 2).

Outbreak metrics

Where applicable, outbreak metrics were defined using the *Guidelines for Foodborne Disease Outbreak Response* developed by the Council to Improve Foodborne Outbreak Response (1). Otherwise, definitions are consistent with those in the CNPHI data dictionary (*Government of Canada. Outbreak Summaries Data Dictionary – Enteric, Food and Water Borne Disease Module. Canadian Network for Public Health Intelligence. n.d.*).

Where available, we extracted or calculated the outbreak metrics defined in **Table 1**.

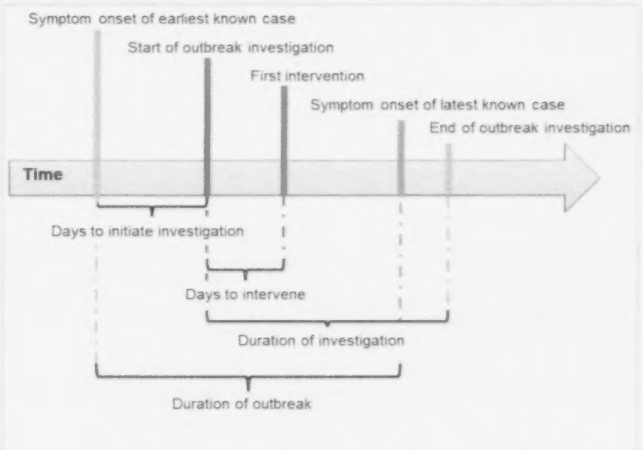
Time-related outbreak metrics are consistent with events of a typical enteric disease outbreak (**Figure 1**). Other variables such as number and type of interventions implemented, etiologic agent, mode of transmission, source details, location of cases, and reporting agency were used to provide context to the results.

Table 1: Definitions of key enteric outbreak metrics

Outbreak metric	Definition
Days to initiate investigation	Interval between date of earliest known symptom and start of outbreak investigation
Days to intervene	Interval between date of start of outbreak investigation and date of implementing first outbreak intervention, if any
Duration of investigation	Interval, in days, between start and end dates of outbreak investigation
Duration of outbreak	Interval, in days, between date of onset of earliest known symptom and date of lastest symptom onset date
Total number of cases	Total number of reported clinical and lab-confirmed cases in outbreak

An intervention was defined as public health action intended to eliminate or decrease exposure to the source of an outbreak or decrease an individual's susceptibility to infection. Types of interventions included actions on facilities (closure, staff exclusion, sanitization) as well as education, immunization, policy changes, press releases and product recalls.

Figure 1: Progression of an enteric disease outbreak and time-related outbreak metrics



Outbreaks were described using counts of cases and days, as well as medians and ranges. Inferential analyses were conducted to uncover preliminary relationships between outbreak investigation activities, the timing of those activities and/or case counts; this was done to inform approaches to evaluate intervention effectiveness in future studies. Fisher's exact test was used to test for statistical significance of relationship between knowledge of outbreak source and use of interventions. Spearman's rank correlation was used to test for statistical significance of relationships between time-related

outbreak metrics (e.g. durations) and case counts. Analyses were performed using statistical package R version 3.2.2 and Microsoft Excel 2010.

Results

Outbreak metrics

Characteristics of the outbreaks are summarized in **Table 2**. From a total of 57 enteric outbreaks involving the BCCDC from 2005 to 2014, the majority (88%, n=50) had cases located in more than one regional health authority and most (79%, n=45) were foodborne. The median number of cases per outbreak of *Salmonella*, *E. coli* O157:H7 and overall were 22.5 (range: 3–1029), 16 (range: 3–85) and 18 (range: 1–1029), respectively. *Salmonella* and *E. coli* O157:H7 were implicated in 63% (n=36) of outbreaks and contributed to 76% (n=2291) of the outbreak-related cases. During the study period, there was a median of six outbreaks investigated per year (range: 3–8) with nearly half (47%, n=27) occurring in the summer (June to August). The source was identified in 46% (n=26) of outbreaks.

Table 2: Characteristics of enteric outbreaks involving the British Columbia Centre for Disease Control, by etiology, 2005–2014

Outbreak metric		*Salmonella*	*E. coli* O157:H7	Other[1]	Total N (%)
		N (%)	N (%)	N (%)	
Outbreaks		24 (42)	12 (21)	21 (37)	57 (100)
Cases		2025 (67)	266 (9)	742 (25)	3033 (100)
Location	International	7 (12)	3 (5)	1 (2)	11 (19)
	>1 province/ territory	9 (16)	8 (14)	8 (14)	25 (44)
	>1 HU/RHA	8 (14)	1 (2)	5 (9)	14 (25)
	1 HU/RHA	0	0	7 (12)	7 (12)
Mode of transmission	Foodborne	18 (32)	10 (18)	17 (30)	45 (79)
	Other[2]	3 (5)	0	1 (2)	4 (7)
	Unknown	3 (5)	2 (4)	3 (5)	8 (14)
Source	Known[3]	12 (21)	6 (11)	8 (14)	26 (46)
	Unknown	12 (21)	6 (11)	13 (23)	31 (54)
Interventions	>1 intervention	14 (25)	6 (11)	7 (12)	27 (47)
	Total	31 (54)	12 (21)	14 (25)	57 (100)

Abbreviations: N, number; HU/RHA, Health Unit/Regional Health Authority; %, percentage
[1] *Cyclospora* (n=5), *Clostridium botulinum* (n=4), *Campylobacter* (n=3), hepatitis A virus (n=3), shellfish poisoning (diarretic/paralytic, n=2), *Shigella* (n=2), *Listeria* (n=1) and norovirus (n=1)
[2] Animal-to-person, person-to-person or contaminated pet treats
[3] Sources identified were primarily food (42.1%, n=24) including meat, vegetables/fruits, seafood, eggs, condiments, seed/nuts/legumes and dairy. Pet treats were implicated in 2 (3.5%) outbreaks

Time-related outbreak metrics are summarized in **Table 3**. Outbreak data were generally available for calculating days to initiate investigation (93% complete, n=53), duration of investigation (77% complete, n=44) and duration of each outbreak (95% complete, n=54). The median time to start an outbreak investigation was 36 days and the median duration of investigations was 39 days. Outbreaks with short times to investigation were less widespread geographically. For example, 85% (n=11/13) of the investigations initiated within 18 days (1st quartile) involved only one province, whereas 92% (n=11/12) of the investigations initiated after 55 days (3rd quartile) had cases in more than one province/territory. In addition, outbreaks with short times to investigation were those with distinct symptoms or etiologic agents with short incubation periods or those that did not require molecular subtyping for links to be established (e.g. paralytic shellfish poisoning, *Clostridium botulinum* and norovirus). In contrast, etiologic agents with long incubation periods, such as hepatitis A virus and *Listeria*, were associated with investigations that took longer than the median 36 days to initiate.

Table 3: Time-related enteric outbreak metrics involving the British Columbia Centre for Disease Control, 2005–2014

Outbreak metric	Median	1st quartile	3rd quartile	Range	N
Days to initiate investigation	36	18	55	0–620	53
Duration of investigation (days)	39	20	78	0–1651	44
Duration of outbreak (days)	40	16	84	0–1689	54
Days to intervene, first intervention	10	4	25	1–106	20
Days to press release	6	4	33	2–140	14
Days to product recall	9	4	19	2–106	16
Days to intervene, other[1] interventions	13	10	25	1–74	6

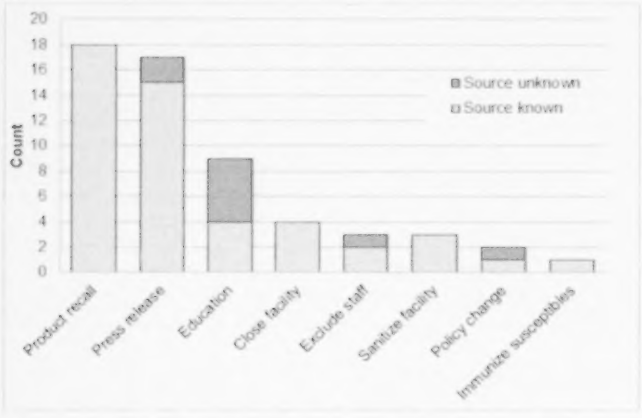
Abbreviation: N, Number
[1] Close facility, education, exclude staff, immunize susceptibles

Outbreak intervention metrics

Almost half (47%, n=27) of the outbreaks had at least one recorded intervention, with most of these (70%, n=19) having no more than two interventions (Table 2). The median number of interventions per outbreak for *Salmonella*, *E. coli* O157:H7 and overall were 1 (range: 0–5), 0.5 (range: 0–3) and 0 (range: 0–5), respectively. Out of a total of 57 interventions documented, most (75%, n=43) were associated with *Salmonella* or *E. coli* O157:H7. Identification of the source was significantly associated with use of one or more interventions ($P<0.0001$). Product recall, facility closure, facility sanitization and immunization were only implemented when a source was identified, whereas press releases, education, staff exclusion and policy changes were implemented irrespective of whether the source was identified (**Figure 2**). Besides product recalls and press releases, other intervention types were reported infrequently or their implementation dates were unavailable; 21 (37%) of 57 interventions had insufficient information to calculate the time

to intervene. Of the 27 outbreaks with at least one intervention, 74% (n=20) had sufficient information to calculate time to intervene. The median time to intervene was 10 days, with product recalls implemented a median of nine days after the start of an outbreak investigation and press releases a median of six days after the start of an outbreak investigation (Table 3).

Figure 2: Frequency and type of interventions used, according to whether the outbreak source was known (n=57)



The duration of outbreaks was positively correlated with the number of days to initiate an investigation (r_s=0.72, P<0.0001) and number of days to intervene (r_s=0.51, P=0.025). The number of days to intervene was also positively correlated with the number of days to initiate an investigation (r_s=0.47, P=0.036). There were no significant correlations between the total number of cases and the number of days to initiate an investigation or days to intervene (r_s=0.16, P=0.27; r_s= −0.082, P=0.73, respectively).

Discussion

At the time of this study, we were not aware of any published analyses of metrics related to enteric disease outbreaks and associated interventions in Canada. We provide information on outbreak metrics that can be used to assess the timing of enteric disease outbreak investigation and intervention.

Implementing interventions

Our findings indicate that identifying the source of an outbreak was associated with implementing interventions. For certain interventions (e.g. product recall), source identification is required as these interventions eliminate the implicated source. Non-specific interventions (e.g. education) can be implemented without knowledge of a definitive source. We found that product recalls, press releases and education were used more often than facility closures and exclusion of ill persons, which is consistent with the fact that our outbreaks tended to be widespread rather than localized or facility-based. FoodCORE found that, between 2010 and 2012, a source was identified in an average of 30% of *Salmonella*, *E. coli* O157:H7 and *Listeria* outbreaks (2). In our study, almost half the outbreaks had a known source (Table 2). This difference is possibly due to more stringent criteria for initiating outbreak investigations in British Columbia since 2011, established to focus on those outbreaks whose source may be more easily identified (7). Source identification is a critical milestone for implementing targeted control actions.

Outbreak duration and total cases

Our findings indicate that as the number of days to initiate an investigation increases, so does the duration of outbreak and number of days to intervene. Similarly, as the number of days to initiating intervention increases, so too does the duration of the outbreak. Where interventions are delayed, disease transmission will continue and lead to longer outbreaks. Our preliminary findings indicate a correlation between timing of outbreak activities and outbreak duration. Further research is required to substantiate these relationships.

Regular tracking of outbreak metrics allows comparison against internal and external benchmarks over time and identification of activities for improvement. FoodCORE has been reporting annual outbreak metrics since 2011 for evaluation of outbreak detection, response and control activities (8–11). They report a median duration of investigation (calculated from cluster notification to end of investigation) for *Salmonella* of 26 to 35 days (12–14); based on our data, we found this median duration of investigation to be 49 days. This difference may be due to our dataset including several large outbreaks (>100 days), including an S. Enteritidis outbreak that spanned four years. Operational differences in outbreak response and surveillance activities may be another reason for the differences in reported duration. Such inherent differences in data sources and operations may limit external comparisons, but internal comparisons over time are valuable for tracking improvements. Collecting outbreak metrics and reporting on how they are used as performance indicators will allow for evaluation and richer analysis of trends, including those for intervention timing.

Although our analysis did not find a significant relationship, one might expect the total number of cases to decrease when investigations or interventions are initiated earlier. One review of European outbreak investigations found no correlation between the timeliness of completing an analytic outbreak study and the total number of cases (5). Still, models have indicated that delays in reporting of the index case to public health increases the proportion of expected infections produced by index and secondary cases (15). Case counts are likely influenced by other factors related to transmission dynamics.

Data limitations and implications for future research

The absence of date information for many interventions limits the ability to conduct further analysis. The pooled data are skewed by the large proportion of *Salmonella* and *E. coli* O157:H7 outbreaks; summary statistics could not be calculated for many other etiologic agents.

Although outbreak investigations may follow a logical sequence of activities, our data were largely cross-sectional in nature, which limits specific inferences about cause and effect. Case counts and time-related outbreak metrics varied substantially and statistical power was limited by a small sample size. Outbreaks reported by regional health authorities that did not involve the BCCDC

were excluded as their scope is operationally distinct (e.g. different settings, management) and required data that were not accessible by the BCCDC. Therefore, the results reported may only apply to situations involving widespread outbreaks (provincial or national).

Since 2011, the BCCDC has established criteria that consider the minimum number and geographic distribution of cases for initiating an enteric outbreak investigation (7). In our results, we see this reflected in the large proportion of foodborne *Salmonella* and *E. coli* O157:H7 multi-jurisdictional outbreaks and small proportion of localized outbreaks from etiological agents with shorter incubation periods primarily spread from person to person (e.g. norovirus). Therefore, any time-related outbreak metrics and interventions should be interpreted in the context of the type of outbreaks included in the analysis.

Thorough and consistent documentation of outbreaks, including complete line lists and dates for outbreak milestones would be needed to further explore the impact of interventions. Additional data and mathematical modelling would be useful for exploring the relationships among intervention timing, duration of outbreaks, the number of cases over time and the expected number of cases averted. Modelling may also permit assessment of combined intervention strategies, which more closely reflects real-world situations. Based on data from previous outbreaks, studies have used models to simulate the expected temporal distribution of cases (epidemic curve) and quantify the effect of interventions (3,4).

Conclusion

This study describes how outbreak data can be used to develop outbreak metrics and use them to evaluate the timing of investigations and interventions. We identified outbreak metrics suitable for establishing baselines. These findings will help determine methodological and data quality considerations for future studies to predict the impact of interventions on outbreak duration and case counts over time. Temporal information of key outbreak milestones is essential. Routine analysis of outbreak data may help identify requirements for action, establish benchmarks, support continuous quality improvement and enhance understanding of the impact of public health activities on the outcomes of an outbreak. We encourage partnerships between agencies to address data gaps and develop evidence-informed approaches to assess the utility of outbreak response and control actions.

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We would like to thank Dr. Jane Buxton for her critical review of the manuscript. We also acknowledge the environmental health officers in British Columbia and across Canada for reporting outbreaks through the Canadian Network for Public Health Intelligence and the local and provincial laboratories for their diagnostic work.

Conflict of interest

None.

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REVIEW

Foodborne and waterborne illness among Canadian Indigenous populations: A scoping review

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Abstract

Background: Indigenous populations are often at higher risk for foodborne illness than the general Canadian population.

Objective: To investigate the extent of the literature on the link between food safety and the occurrence of foodborne and waterborne illness in Canadian Indigenous populations.

Methods: A scoping review was conducted using search strings in five databases and grey literature to identify all papers that studied a Canadian Indigenous population and referred to any potential associations between food safety (including consumption and preparation of traditional foods and retail foods) or water safety practices and food or waterborne illness. Two authors screened papers based on inclusion and exclusion criteria. Included documents were analyzed for emergent themes.

Results: From 1,718 unique records identified, 21 documents were selected. Foodborne illness was most common in children up to 14 years old. Walrus, seal, caribou and whale were the most common traditional foods tied to foodborne illness and were primarily associated with botulism and trichinosis. Aside from consuming the food raw, fermentation was the most common traditional food preparation method linked to foodborne illness. There was concern about the safety of retail food but no clear link was identified with foodborne illness. Lastly, although there was concern about tap water, the use of alternate water sources, such as untreated brook water, and hygiene and cleaning practices in communities with boil water advisories were the most common risk behaviours associated with waterborne illness.

Conclusion: Consumption of certain game meats, as well as the use of traditional fermentation practices may lead to an increased risk of foodborne illness among Indigenous populations. Concern about tap water may lead to use of unsafe alternate water sources. Further research is needed to examine potential culturally appropriate food and water safety opportunities.

Suggested citation: Jung JKH, Skinner K. Foodborne and waterborne illness among Canadian Indigenous populations: A scoping review. Can Commun Dis Rep. 2017;43(1):7-13.

Introduction

Foodborne and waterborne illness are important public health issues worldwide, with morbidity and mortality affecting both developed and developing countries (1,2). Primarily caused by bacteria, viruses and parasites, foodborne illness and waterborne illness typically present in the form of gastrointestinal symptoms (3,4). In Canada, it is estimated that foodborne illness affects about one in eight Canadians (four million cases) each year (3). However, the burden of foodborne illness is not distributed equally, as the risk of enteric illness is believed to be higher in many Indigenous communities compared to the national average (5). Likewise, these communities also face increased risk of waterborne illnesses, particularly due to environmental factors (6).

There are several reasons for the higher risk of foodborne and waterborne illness in Indigenous communities. A large proportion of Indigenous people are included in the groups at most risk: infants, young children, pregnant women and the elderly (7). However, another reason for the higher prevalence can be linked to preparation methods and consumption of traditional foods. For example, the consumption of meat—such as seal, whale, walrus and caribou—in raw form is common among some Indigenous groups, which poses a health risk from pathogens normally destroyed by proper cooking (7). Non-adherence to boil water advisories in Canadian Indigenous communities can also affect the risk of contracting waterborne illness (5,8,9).

To our knowledge, a comprehensive review of foodborne and waterborne illness among Canadian Indigenous populations caused by food and water safety practices has not been conducted. Thus, a scoping review was performed because it is most useful when no comprehensive review exists. The objective of this scoping review was to investigate the extent, nature and range of studies on the link between food safety and occurrence of foodborne and waterborne illness in Canadian Indigenous populations.

Methods

This scoping review followed the five-step framework developed by Arksey and O'Malley (10). First we established the research question: "What is currently known about the connection between food safety and occurrence of foodborne/waterborne illness in the Canadian Indigenous population?" Food safety was defined as the handling, preparation and storage of food to preserve the quality of the food and prevent contamination (11) and also included the preparation and consumption of traditional foods. Traditional foods are those obtained from local plant or animal sources through gathering or harvesting, possess cultural meaning (12) and are generally synonymous with the terms "wild food" and "country food". We included the risk for waterborne illness if it was related to individual/community behavioural practices and not solely due to environmental contamination. We considered all forms of disease caused by contaminated food or water sources, and not merely those related to acute gastrointestinal illness (for example, we included hepatitis A in our search). We chose the term "Indigenous" to refer collectively to First Nations, Métis and Inuit peoples. However groups were also reported in the way they were described in the studies.

Study identification

A research librarian guided the development of relevant search strings for five academic databases (**Appendix**). Due to the broad definition of food safety, this term was not included in the search strategy, but was used as part of the inclusion and exclusion criteria when screening (**Text box**). Journals (not indexed in the databases) and publications by a selection of authors who study food consumption among Indigenous populations were also hand searched (Appendix). All returned citations were exported into RefWorks©.

Inclusion and exclusion criteria for scoping review

Inclusion criteria:

- The population is strictly Indigenous AND in Canada
- Address an association between foodborne illness and (minimum one paragraph):
  - Food safety/contamination/supply and/or
  - Traditional foods and/or hunting
  - Other lifestyle factors unique to the Indigenous population
- Address an association between waterborne illness and (minimum one paragraph):
  - Unsafe water supply AND
  - Water safety and other behavioural practices of the Indigenous population

Exclusion criteria:

- Studies investigating cultures of foodborne pathogens and/or their mechanisms with no relationship to the Indigenous lifestyle
- Advisories to prevent foodborne/waterborne illness with no mention of actual cases
- Investigation of chronic conditions: (e.g., diabetes, cardiovascular disease, alcohol, tobacco)
- Non-human samples
- Not written in English
- Not available in full-text
- Not a primary journal article, government report, thesis or case report
- Duplicate
- For waterborne illness only: Illness solely due to environmental factors, rather than being linked to behavioural practices

A custom Google search engine that captured the websites of Canada's federal and provincial health departments and public health agencies was used to access grey literature (13,14). A dissertation and thesis database was also used as well as three federal government websites (Appendix). For the grey literature search, several searches were conducted using different combinations of key terms instead of one systematic search string (12; Appendix).

Study selection

Titles and abstracts of all returned citations were screened based on a priori inclusion/exclusion criteria. Two independent reviewers scanned the full-text documents using the criteria for final inclusion. Conflicts were discussed between reviewers and the criteria was revisited until an agreement could be reached. Cohen's Kappa (k) was used to assess inter-rater agreement between the reviewers, where k=0.7 was considered sufficient. There was no limit on the year of publication. For duplicate documents from the same study (multiple publications based on the same data) or report (revised version of previous year's report), the document with the most relevant information was chosen.

Data collection, analysis and reporting

Information collected from each document included: author(s), publication year, location of study in Canada, specific Indigenous population, type of document, study objective, number of cases, type of illness addressed, specific pathogen addressed and reported main health outcomes. Results were summarized through qualitative thematic analysis and emerging themes. Demographic variables such as age, sex and community-level factors were explored for potential connections to foodborne and waterborne illness. Specific types of traditional foods consumed by those who became ill, as well as preparation methods linked to illness were reported. The role of retail food (or purchased food) in Indigenous communities that may lead to increased risk for illnesses was examined, and any water safety practices in connection to waterborne illness were recorded. As with most scoping reviews, a formal quality assessment of the studies was not conducted (9).

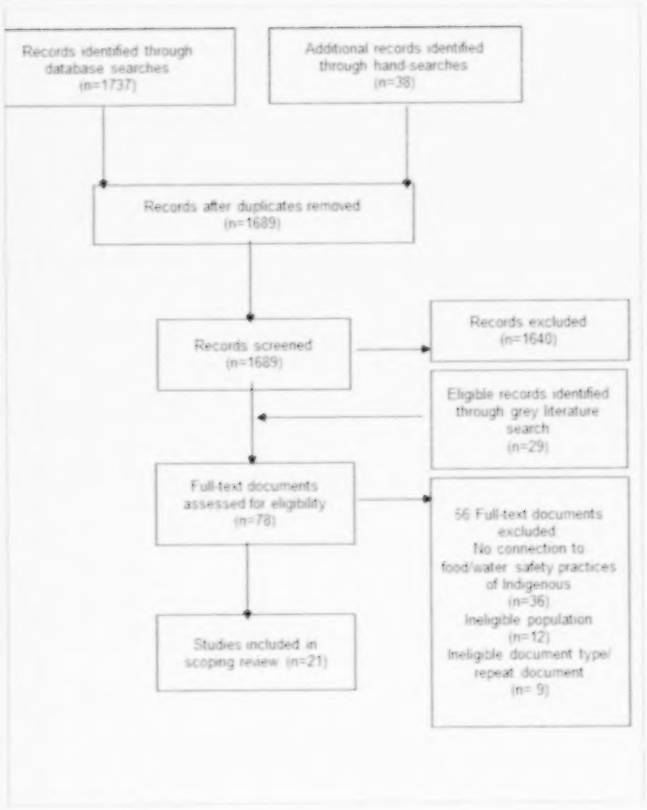
Results

From the 1,718 unique records identified through databases, hand-searches and grey literature, 21 documents (20 journal articles and one report) were included for the qualitative analysis (**Figure 1**). Reasons for exclusion are noted in Figure 1. There was reasonably strong agreement between reviewers at the full-article screening level (k=0.75).

Demographic and social factors

Of the 21 documents reviewed, eight (38%) reported trends between age and the occurrence of foodborne and waterborne illness (7,8,19,25,28-31). Of these, six (75%) noted higher prevalence in children up to 14 years old (7,19,28-31). One study did not report any difference due to age (8) and one showed that most of the trichinosis cases were in those over 60 years old and were more likely to be female (25). Of the six documents that reported some form of trend by male/female gender, half noted approximately equal distribution for botulism (16), *E. coli* (28) and hepatitis A (30,31). Overcrowding in homes was noted in four articles, particularly during winter (5,29,30,31). Two studies (8,29) reported that tight social networks in small remote communities may be another possible mode of transmission for foodborne illness. One document (7) identified the practice of sharing food among family and community members, after a hunt or harvest, as a potential vehicle for foodborne illness transmission.

Figure 1: Flow diagram of screening process


Records identified through database searches (n=1737)
Additional records identified through hand-searches (n=38)
Records after duplicates removed (n=1689)
Records screened (n=1689)
Records excluded (n=1640)
Eligible records identified through grey literature search (n=29)
Full-text documents assessed for eligibility (n=78)
56 Full-text documents excluded
No connection to food/water safety practices of Indigenous (n=36)
Ineligible population (n=12)
Ineligible document type/ repeat document (n= 9)
Studies included in scoping review (n=21)

Foodborne illness

There were 16 studies on foodborne illness (**Table 1**). Of these, 15 (94%) were in Inuit populations, and the next most common was First Nations of British Columbia. The most common place of study was in the Northwest Territories (50%); Nunavut, British Columbia, Quebec, Ontario, and Manitoba were other places studied.

Type of traditional foods and traditional preparation methods

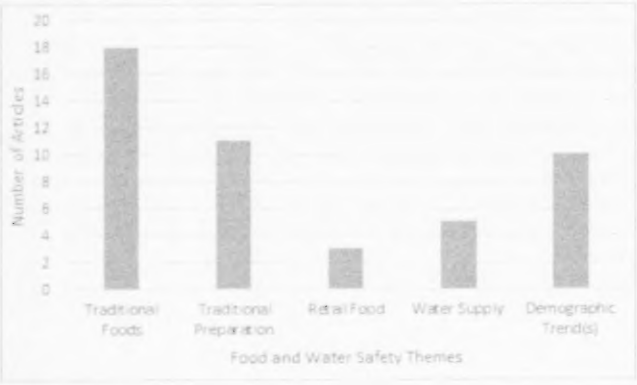
The main themes addressed by the studies are listed in **Figure 2**. Of the 18 relevant studies, walrus (44%), seal (39%), caribou (39%) and whale (33%) were the most commonly mentioned traditional foods tied to foodborne illness, especially when eaten raw. Other traditional foods linked to illness included fermented salmon eggs (stink eggs) (7,16,21–23) and fish (such as char, salmon and trout (5,7,21). Aside from raw meat consumption, the fermentation of traditional foods was the most common traditional preparation method involved in foodborne illness (7,16,20–23,25,26). This was most commonly linked with seal (7,20–23), walrus (7,20,25,26) and stink eggs (7,16,19,20). It was noted that the fermentation methods used by the First Nations and Inuit do not produce lactic acid, acetic acid, or ethanol to inhibit the growth of pathogens (7). Traditional Indigenous fermentation methods have been noted as more of a decomposition or putrefaction process and the low pH required to inhibit the growth of pathogens may not be achieved (21).

Table 1: Canadian studies on foodborne illness in Indigenous populations

Population and location (Ref.)	Study objective (cases)
Inuit in Labrador and Nunavut (5)[†]	To estimate the burden of community-level self-reported acute gastrointestinal illness in Inuit communities of Rigolet, Labrador (n=30) and Iqaluit, Nunavut (n=72)
Inuit, First Nations, Métis across Canada (7)[†]	To identify food safety issues associated with traditional/country foods and environmental factors, and to assess the effectiveness of programs aimed at decreasing the number of foodborne illnesses
Inuit in Labrador (8)[†]	To understand the lived experience of acute gastrointestinal illness in a small Inuit community of Rigolet, Canada (n=30)
First Nations in MB and Inuit in NWT (9)	To examine causes of diarrhea in Winnipeg and Berens River, Manitoba and Eskimo Point, NWT (n=172)
Inuk in Inuvialuit, NWT(15)	To identify the cause of botulism of a 58-year-old Inuvialuit woman (n=1)
Inuit in Nunavik, QC and First Nations across BC (16)	To summarize botulism cases in Canada from 1985 to 2005 (n=205)
Inuit, First Nations, and Métis across NWT (17)	To examine community-level risk factors for notifiable gastrointestinal illnesses in Northwest Territories (n=708)
Inuit in Nunavik, QC (18)	To review the effectiveness of the Nunavik Trichinellosis Prevention Program (n=95)
Inuit in Nunavut (19)	To describe brucellosis cases and the bacteriological investigation of the organisms isolated (n=7)
Inuit in Nunavik, QC (20)	To summarize four unrelated outbreaks of botulism in Ungava Bay, Nunavik, Quebec (n=9)
Mainly Inuit across QC, NWT and BC (21)	To summarize botulism cases in Canada from 1971 to 1984 (n=113)
First Nations of BC and ON and Inuit, across QC and NWT (22)	To summarize botulism cases in Canada from 1971 to 1974 (n=42)
First Nations of BC and ON and Inuit across QC and NWT (23)	To summarize botulism cases in Canada from 1919 to 1973 (n=122)
Inuit in Nunavut and QC (24)	To present three outbreaks of botulism in Cape Dorset and Frobisher Bay, Nunavut; and Wakeham Bay, Quebec among Eskimos during 1967-1969 (n=9)
Inuit in Nunavut (25)	To describe an outbreak of trichinellosis on Baffin Island, August-September 1999 (n=34)
Inuit in QC (26)	To describe an outbreak of trichinosis after the consumption of raw walrus meat in 10 Inuit inhabitants of Saluit, Quebec. (n=10)
Inuit in NWT (27)	To examine the cause of brucellosis in a nine year old Inuit boy (n=1)
Inuit in NWT (28)	To describe the clinical and epidemiologic features of an outbreak of verotoxin-producing *Escherichia coli* associated diarrhea in Keewatin, NWT (n=152)
Inuit in NWT (29)	To evaluate risk factors for childhood hemolytic-uremic syndrome and gastroenteritis during an epidemic of *E. coli* O157:H7 infection in Arviat, Nunavut (n=84)
First Nations of BC (30)[‡]	To determine if hepatitis A incidence is higher in Aboriginal people than total BC population and if this is associated with poverty and unsanitary living conditions (n=2,933)
First Nations of Northern BC (31)[‡]	To describe the outbreak of hepatitis A in the Northern Interior Health Region of BC and the public health response (n=23)

Abbreviations: Ref., Reference number; NWT, Northwest Territories; BC, British Columbia; ON, Ontario; QC, Quebec; MB, Manitoba
[†] Study included both foodborne and waterborne illness
[‡] Study focused on waterborne illness

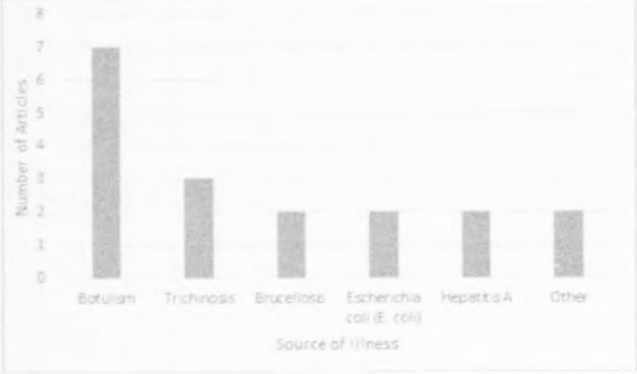
Figure 2: Themes related to food and water safety identified from included studies (n=21)



Types of infection

The most common types of infection reported are noted in **Figure 3**. Almost one third of the articles (n=7) discussed botulism (15,16,20,24). Trichinosis was discussed in almost 15% of studies. Brucellosis, *E. coli* and hepatitis A were identified in about 10% of studies. Brucellosis, was specifically linked with the consumption of caribou (19,27) populations.

Figure 3: Common sources of gastrointestinal illness identified in included studies (n=21)



Retail food

In a review of food safety and Aboriginal traditional foods, some studies showed Indigenous people were concerned about the safety of retail food but few assessed the correlation between retail food and foodborne illness in Indigenous populations (7). One study suggested that retail food could have been a factor for acute gastrointestinal illness in an Inuit community (8) and another found the odds of developing acute gastrointestinal illness were increased if the person responsible for food preparation was employed (5). The authors suggested that those with higher income may have less time to access country food and instead consumed more retail food, but this was not confirmed. Conversely, a study in the Northwest Territories (17) found the higher the food prices in native communities, the lower the risk was for campylobacteriosis. The authors proposed that the higher food prices may lead to lower consumption of retail meat, dairy and fruits and vegetables and choosing processed items, which could reduce exposure to pathogens more commonly observed in perishable foods.

Waterborne illness

Table 1 identifies that about one-quarter of all studies addressed unsafe water practices in Indigenous communities associated with either water or foodborne illness (5,7,8,30,32). Three documents (5,7,8) mentioned the preference of Indigenous communities to drink alternative water sources such as bottled water and untreated brook water rather than tap water. One article (8) mentioned how Inuit members in Rigolet, Labrador, perceived tap water to be a potential risk factor for acute gastrointestinal illness, while viewing untreated brook water to be safe. However, in a similar study (5), which included the same members of Rigolet, the consumption of these tap water alternatives was associated with developing acute gastrointestinal illness. There was also concern regarding non-compliance to boil water advisories, a potential contributing factor to developing waterborne illness in two studies (8,31). Lastly, one article (30) noted how community water supply problems (which led to higher incidence of hepatitis A in this study) may also lead to infrequent hand-washing or inadequate cleaning as the water quality may be viewed as unreliable. In turn, that can serve as a further disease vector.

Discussion

This article provides the most up-to-date review of studies on food safety and unsafe water practices in Indigenous populations in Canada leading to foodborne and waterborne illness. Most studies reported that foodborne illnesses occurred primarily in children up to 14 years of age and females, and that overcrowded housing and food sharing may be potential vehicles for transmission of illness. Walrus, seal, caribou and whale—especially when eaten raw or were fermented by processes that do not inhibit the growth of pathogens—were associated with an increased risk for foodborne illness.

There are several limitations to consider when reviewing these results. First, the review identified only 21 studies conducted over the last 50 years. Error and bias could have been introduced during the screening process, with some articles being missed or incorrectly included/excluded in the review. Additionally, the search was limited to documents in the English language. We identified studies that reported the belief that retail food consumption was linked to foodborne illness but there is currently no evidence for this, therefore it deserves further study. Likewise, a fear of tap water was reported and although this has been a problem in some Indigenous communities (32), it is uncertain whether it is linked with illness in all communities. It appears the risk of drinking untreated brook water may be underestimated which deserves further study.

Future research

Overall, Indigenous populations in Canada face unique sources of infections due to environmental and social factors. More research is needed to better understand these issues and whether different public health approaches may be needed for effective prevention. When researching ways to decrease foodborne illness and unsafe water practices in Indigenous communities, cultural implications should be considered. For example, it is important to acknowledge that although foodborne illness may be linked to the consumption of traditional foods, these foods also have many health benefits and are essential to wellbeing. The preparation and consumption of traditional foods help to reinforce Indigenous culture and identity (33) and contribute to the total diet, as they are rich in

iron, zinc and protein (34). Likewise, although food sharing was associated with foodborne infections, Indigenous populations value social connectedness which brings many benefits to their health, well-being, spirituality and community spirit. All these factors should be carefully considered when developing food safety guidance. Programs are more likely to be effective if they are designed with community input and respect for Indigenous knowledge systems and cultural food ways (7). For example, the government of Nunavut has been developing guidelines for food safety when serving country food in government-funded facilities and community programs (35). These guidelines could be considered and applied in other contexts.

The influence of climate change on foodborne illnesses in Indigenous communities and its impact on the health care system merits further examination. This is particularly relevant as higher temperatures may result in increasing temperature-sensitive foodborne illnesses such as botulism (7,36) which in turn may result in significant financial costs to the health care system.

Conclusion

There is limited research that examines the unique food safety and water safety challenges that Indigenous populations in Canada face that may be associated with their environment, traditional foods, and food preparation techniques as well as social and cultural beliefs and practices. It appears that consumption of certain game meats, as well as the use of traditional fermentation practices, may lead to increased risk for foodborne illness among the Indigenous population. Further research is needed to inform culturally appropriate food safety practices.

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Conflict of interest

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Appendix: Databases used and search strategy

Databases Used:

1. PubMed
2. Scopus
3. Cumulative Index of Nursing and Allied Health Literature (CINAHL)
4. Bibliography of Native North Americans
5. Sociological Abstracts

Database Example - PubMed Search Terms:

(gastrointestinal disease*[tw] OR gastrointestinal illness*[tw] OR gastroenteritis[tw] OR intestinal disease*[tw] OR enteric disease*[tw] OR enteritis[tw] OR enterocolitis[tw] OR foodborne disease*[tw] OR foodborne illness*[tw] OR food poisoning[tw] OR waterborne disease*[tw] OR waterborne illness*[tw] OR diarrhea[tw] OR dysentery[tw] OR amebiasis[tw] OR botulism[tw] OR brucellosis[tw] OR campylobacter[tw] OR cholera[tw] OR cryptosporidiosis[tw] OR cyclosporiasis[tw] OR giardiasis[tw] OR hepatitis A[tw] OR legionellosis[tw] OR listeriosis[tw] OR shellfish poisoning[tw] OR salmonella infection*[tw] OR salmonellosis[tw] OR shigellosis[tw] OR trichinellosis[tw] OR trichinosis[tw] OR escherichia coli[tw] OR yersinia infection*[tw] OR yersiniosis[tw] OR typhoid fever[tw] OR paratyphoid fever[tw] OR gastrointestinal diseases[MeSH:noexp] OR gastroenteritis[MeSH] OR intestinal diseases[MeSH:noexp] OR enteritis[MeSH] OR enterocolitis[MeSH] OR foodborne diseases[MeSH] OR diarrhea[MeSH] OR dysentery[MeSH] OR amebiasis[MeSH] OR brucellosis[MeSH] OR campylobacter[MeSH:noexp] OR cholera[MeSH] OR cryptosporidiosis[MeSH] OR cyclosporiasis[MeSH] OR giardiasis[MeSH] OR hepatitis A[MeSH] OR legionellosis[MeSH] OR listeriosis[MeSH] OR salmonella infections[MeSH] OR trichinellosis[MeSH] OR escherichia coli[MeSH] OR yersinia infections[MeSH]) AND (((inuit[tw] OR rigolet[tw] OR "first nations"[tw] OR metis[tw] OR cree[tw] OR ojibway[tw] OR oji cree[tw] OR nunavut[tw] OR yukon[tw] OR "northwest territories"[tw] OR "northern ontario"[tw] OR arctic[tw] OR subarctic[tw] OR inuits[MeSH] OR nunavut[MeSH] OR yukon[MeSH] OR "northwest territories"[MeSH]) OR ((Canada[tw] OR Canadian[tw] OR Canada[MeSH]) AND (aborgin*[tw] OR indigen*[tw] OR native[tw] OR natives[tw])))

Grey Literature Database and Websites Used:

1. A custom Google search engine (captures websites of Canada's federal and provincial health departments and public health agencies)
2. ProQuest Dissertations and Thesis Global Database
3. Federal Government Websites
    a. Health Canada
    b. Public Health Agency of Canada
    c. Canadian Food Inspection Agency

Grey Literature Search Terms

Search 1. Foodborne illness AND Aboriginals OR First Nations

Search 2. Foodborne disease AND Aboriginals OR First Nations

Search 3. Waterborne disease AND Aboriginals OR First Nations

Search 4. Waterborne illness AND Aboriginals OR First Nations

Search 5. Gastrointestinal illness AND Aboriginals OR First Nations

Search 6. Diarrhea AND Aboriginals OR First Nations

Search 7. Food safety AND Aboriginals OR First Nations

Search 8. Food poisoning AND Aboriginals OR First Nations

*The eight search strategies were applied to each search engine with up to 50 records being screened for each search (totalling to 400 records per search engine).

Outbreak of *Salmonella* Reading in persons of Eastern Mediterranean origin in Canada, 2014–2015

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Abstract

Background: *Salmonella* Reading (*S.* Reading) is a rare serotype of *Salmonella* subspecies (spp.) in Canada with less than nine cases reported each year (2011–2013). An increase in *S.* Reading was identified in several Canadian provinces in early 2015, prompting the initiation of a national outbreak investigation.

Objectives: To describe a multi-provincial *S.* Reading outbreak in Canada that affected over 30 people.

Methods: Cases were defined as laboratory-confirmed *S.* Reading with related pulsed-field gel electrophoresis (PFGE) patterns. Onset dates were between November 2014 and September 2015.

Early in the investigation, investigators noted cases were predominantly of Eastern Mediterranean origin, mainly Afghan and Lebanese and many of those affected had consumed food items not typically captured on standard enteric outbreak hypothesis-generating questionnaires. An open-ended three day food consumption survey was conducted with a convenience sample of community informants to better understand food preferences of the affected ethnocultural populations. Results of the survey were used to design a focused questionnaire for case re-interviews and subsequent outbreak cases. Public health investigators obtained food samples from case homes and relevant food premises. Food safety authorities conducted traceback of suspected food items and collected food samples for laboratory testing.

Results: There were 31 confirmed cases (Ontario=23, Alberta=7, New Brunswick=1) and three probable (Ontario=2, Alberta=1) cases of *S.* Reading identified as part of the outbreak. The median age was 31 years (range less than one to 85 years) and 53% (18/34) of cases were female. Seven cases were hospitalized. No deaths were reported. Most cases were of Eastern Mediterranean origin (n=23) or had reported consuming Eastern Mediterranean foods (n=3). The predominant ethnic origins reported by cases were Afghan in Ontario (n=12) and Lebanese in Alberta (n=3). Genetic similarity of clinical isolates was further confirmed using whole genome sequencing.

Three ethnic bakeries were identified as possible common exposures for the cases; however, traceback of foods of interest from these bakeries did not identify a common supplier and the source of the illness was not identified. In total, 227 food samples from retail premises (n=142), restaurants (n=13) and case homes (n=72) were tested; two food samples, kalonji seeds and tahini, were positive for *S.* Ruiru and *S.* Meleagridis. These products were recalled from the marketplace.

Conclusion: Despite extensive epidemiological, microbiological and food traceback investigations, a common source was not identified for this *S.* Reading outbreak. Challenges included lack of familiarity with the food items consumed in affected ethnocultural groups, as well as a lack of background data on expected food exposures in the outbreak population. Engaging local partners helped build understanding of food preferences in affected communities. Given Canada's ethnic and cultural diversity, culturally competent approaches to enteric outbreak investigations and food consumption surveys may be useful.

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Introduction

Salmonellosis is one of the most common causes of food-borne outbreaks and typically results in diarrhea, fever and abdominal pain. The most common species of this gram-negative bacteria is *S. enterica* and this is further divided into six subspecies and many serotypes (or serovars). *S.* Reading is a rare serotype in Canada: there were seven cases reported in 2012 to the National Enteric Surveillance Program (NESP) and nine cases reported in 2013 (1,2). The NESP is a laboratory-based surveillance system that provides weekly analysis and reporting for laboratory-confirmed cases of enteric pathogens in Canada. The objective of this article is to describe a multi-provincial *S.* Reading outbreak in Canada that affected over 30 people.

Outbreak detection

On January 21, 2015, the NESP identified an increase in reported cases of *S.* Reading in Alberta (n=2) and British Columbia (n=2). One week later, on January 27, 2015, the NESP identified an increase in *S.* Reading in Ontario (n=4). Public Health Ontario opened an Ontario outbreak investigation on February 4, 2015. As additional cases began to occur in Alberta, a national outbreak investigation coordinating committee was activated as per Canada's Foodborne Illness Outbreak Response Protocol (FIORP) (3).

Methods

Case findings

Cases were identified between January 21 and August 25, 2015. The case definitions used during this investigation were:

***Salmonella* Reading outbreak case definitions**

Confirmed	A resident of or visitor to Canada with: • Laboratory confirmation of *S.* Reading AND • PFGE[1] pattern combination ReadXAI.0011/ReadBNI.0005 OR ReadXAI.0012/ReadBNI.0005 OR ReadXAI.0014/ReadBNI.0005 AND • Symptom onset on or after November 1, 2014
Probable	A resident of or visitor to Canada with: • Laboratory confirmation of *S.* Reading AND • PFGE[1] pending OR Epi-link[2] to the current investigation • Symptom onset on or after November 1, 2014

[1] Abbreviation: PFGE, Pulsed-field gel electrophoresis
[2] A person of Eastern Mediterranean descent or who reports exposure to Eastern Mediterranean-style foods in a province with a confirmed case

Questionnaires and exposures

Initial public health investigations were conducted by public health units for all salmonellosis cases, as per routine practice. Outbreak case questionnaires were collected and centrally analyzed by the investigation team where available. Until May 4, 2015, available cases were re-interviewed using a standardized hypothesis-generating questionnaire. Interviews focused on foods identified during initial case follow-up and thought to be frequently consumed by individuals of Eastern Mediterranean origin (see definition below). These included sesame seeds, tahini, pistachios and black (onion/nigella/kalonji) seeds. Supplementary questions were developed to identify a possible link between cases in Alberta and Ontario (e.g. a visitor from Ontario and/or food brought directly from Ontario to Alberta).

In May 2015, field epidemiologists were deployed to assist the investigation team and to collaborate with local public health units and community partners as they conducted an open-ended, detailed three day food consumption survey. Participants were made up of convenience samples of populations affected by the outbreak to identify additional food items typically consumed. In-person interviews were conducted, using approaches that aimed to respect cultural differences and adapt services to meet unique needs within the identified culture (4,5). In Alberta, an environmental health officer fluent in Arabic participated in case interviews and three day food consumption surveys and cases were re-interviewed in their homes. In Ontario, volunteers from the affected groups (community informants) were interviewed in community-based settings (e.g. community centres). Findings of the three day food consumption survey informed the development of a focused questionnaire.

Case ethnicity was self-reported in interviews and/or estimated from reported food exposures. For this investigation, Eastern Mediterranean backgrounds were defined, as per the World Health Organization (WHO), as individuals who identified their ethnicity as linked to countries in the Eastern Mediterranean region: i.e. Afghanistan, Bahrain, Djibouti, Egypt, Iran (Islamic Republic of), Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, Pakistan, Qatar, Saudi Arabia, Somalia, Sudan, Syrian Arab Republic, Tunisia, United Arab Emirates and Yemen (6).

Laboratory investigation

Pulsed-field gel electrophoresis (PFGE) was done on all *S.* Reading isolates. A request was then sent to PulseNet USA and PulseNet International to find PFGE matches to this cluster. An EPIS (European Centre for Disease Control's [ECDC] Epidemic Intelligence Information System) notification was used to inquire whether any PFGE matches to the isolates in this cluster had been reported to the ECDC. Whole genome sequencing (WGS) was conducted for cases and select background isolates. A maximum-likelihood phylogenetic tree, generated through the use of the SNPhyl pipeline developed by the Bioinformatics Unit of the National Microbiology Laboratory, was used to determine the level of relatedness among isolates based on single nucleotide variant positions (SNVs). SNV Phyl phylogeny was built using 642 hqSNVs identified across 93% of the reference genome (SPAdes assembled genome of isolate 15-0793).

Food safety investigation

Food premises (retail and restaurants) of interest were identified from case interviews. The food safety investigation focused initially on products containing sesame seeds, kalonji seeds and tahini. Halal beef, spices and pistachios were also investigated.

Local public health units in Alberta and Ontario (in partnership with regional Canadian Food Inspection Agency [CFIA] staff) visited the case homes and food premises (restaurants and retail)

identified by cases in interviews. For food premises, review of handling practices for relevant food items was conducted using a modified Hazard Analysis Critical Control Point (HACCP) approach. Samples were taken from food premises and case homes for testing at Alberta Provincial and Public Health Ontario laboratories. A list of suppliers was obtained from establishments and common suppliers were identified. Product distribution information was also collected for bakery products from retail food premises of interest.

Supplier and distributor information for sesame seeds, onion/ kalonji seeds, tahini, pistachios, Halal chicken and Halal beef was collected by the CFIA from Ontario and Alberta food premises reported by cases. In addition, the CFIA collected supplier information from two ethnic bakeries identified by cases in Ontario and Alberta.

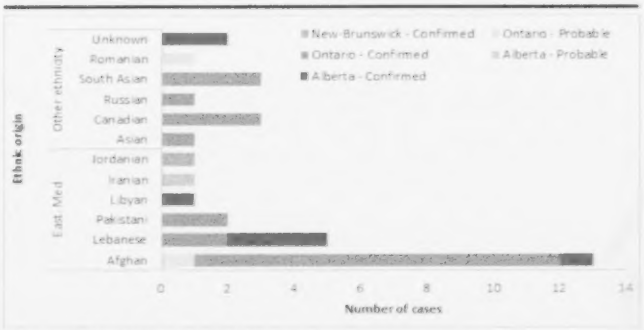
Results

Descriptive epidemiology

There were 31 confirmed (ON=23, AB=7, NB=1) and three probable (ON=2, AB=1) cases included in this investigation. Illness onset dates ranged from November 7, 2014 to July 24, 2015 (see **Figure 1**). The median age was 31 years (range less than one to 85 years), 53% (18/34) of cases were female. Seven cases were hospitalized. No deaths were reported.

Most cases reported being of Eastern Mediterranean origin (n=23) or consuming Eastern Mediterranean foods (n=3). The predominant ethnic origins among cases were Afghan (n=12) in Ontario and Lebanese (n=3) in Alberta (**Figure 2**). The New Brunswick case reported travel to Ontario during the exposure period.

Figure 2: Outbreak-related *Salmonella* Reading cases by ethnic origin and province, Canada, November 1, 2014 to September 11, 2015 (n=34)



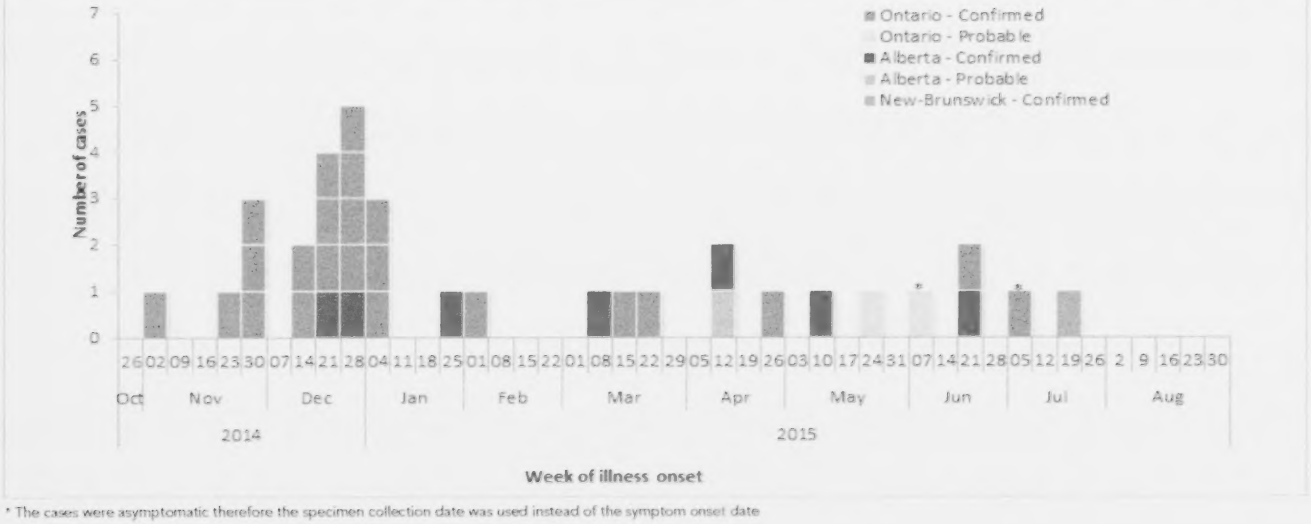
Abbreviation: East. Med., Eastern Mediterranean

Laboratory findings

The three PFGE combinations in the outbreak (ReadXI.0011/ ReadBNI.0005, ReadXAI.0012/ReadBNI.0005 and ReadXAI.0014/ ReadBNI.0005) were highly similar and were considered genetically identical through WGS analysis (**Figure 3**). None of the three PFGE pattern combinations had previously been identified in Canada, USA, Caribbean or Central and South America.

The PFGE pattern combinations ReadXAI.0015/ ReadBNI.0007 (n=1) and ReadXAI.0018/ ReadBNI.0010 (n=2) were both new pattern combinations that were not considered closely related to the patterns associated with confirmed cases; cases with these patterns were included in the outbreak investigation as probable cases based on their exposure to Eastern Mediterranean food. These isolates were not included in the WGS.

Figure 1: Confirmed and probable *Salmonella* Reading outbreak cases by week of illness onset and province, Canada, November 1, 2014 to September 11, 2015 (n=34)



* The cases were asymptomatic therefore the specimen collection date was used instead of the symptom onset date

Figure 3: Whole Genome sequencing (WGS) for *Salmonella* Reading cases, National Microbiology Laboratory - Public Health Genomics Unit

Reference: 15-0793. Method: NML Bioinformatics SNVPhyl Pipeline, Maximum-likelihood phylogenetic tree based on 642 high quality core genome single nucleotide variant (SNV) positions identied amongst 37 isolates over 93% of the reference genome. Context: US isolates, 1502Read12MF (ReadXAI.0012, ReadBNI.0005, ReadXAI.0011, ReadXAI.0014)

Exposure history

Food items reported most frequently among cases were bread (27/27, 100%), chicken and Halal chicken (23/26, 88% and 15/16, 94% respectively), black pepper (12/12, 100%), Halal beef (13/16, 81%) and pita bread (10/11, 91%). Turmeric (10/13, 77%), dried fruits (13/19, 68%), sesame seeds (14/24, 58%) and pistachios (12/21, 57%) were also reported at a higher frequency but no specific commonalities between the cases were noted.

Given the shape of the epidemic curve and the long range in case onset dates, the investigation focused on the hypothesis that a shelf stable food item was the potential source of the outbreak. Initially, sesame seeds, tahini, kalonji/black seeds and Eastern Mediterranean baked goods ('sweets'), including ingredients/toppings on sweets, such as pistachios, were suspect food items and hypothesized as potential outbreak sources. Following re-interview of Alberta cases, as well as data collected from open-ended food histories with members of the affected community, Halal beef was also hypothesized as a common source of exposure.

In some instances, cases were reluctant to provide information on foods eaten in the three days prior to illness onset. Open-ended interviews with community key informants of Eastern Mediterranean origin in both Ontario and Alberta uncovered recurring themes that suggest potential barriers to eliciting this information (see **Text Box**).

Qualitative exposure history findings: Potential barriers to collecting three day food exposure information:

- Language was viewed as a common barrier by both interviewers and respondents.
- Multiple names for the same food/dish: Uncertainty or lack of familiarity among investigators, which was mitigated by help from an interpreter.
- Questions using unclear terms: Uncertainty among some respondents about what foods/dishes were considered 'typical' or 'Eastern Mediterranean'.
- Perceived lack of trust of government officials among some newcomers when asked about foods recently consumed, cooking practices or sampling foods/spices from home kitchens.
- Gender: Gendered food preparation roles may have resulted in challenges eliciting information from males in households where females typically prepared food.
- Positive response bias: Some respondents may have provided public health investigators with socially desirable responses to questions about food preparation which did not reflect actual practice, such as cooking meat thoroughly versus eating raw meat.

Food safety investigation

Food samples for laboratory testing were obtained from case homes, restaurants and retail food premises. In total, over 200 samples were tested by the CFIA, Public Health Ontario and Alberta provincial laboratories for presence of *Salmonella* spp. A summary of food samples collected and microbiologic results is provided in **Table 1**. One sample of tahini sauce tested positive for *Salmonella* Ruiru (recalled on February 26, 2014) and one sample of kalonji whole seeds tested positive for *Salmonella* Meleagridis (recalled on March 1, 2015).

Table 1: Summary of food sample results

Sampling location	Foods sampled	Number of samples	Results of microbiologic testing for *Salmonella* spp.
Tested by the Ontario Provincial Laboratory			
ON case homes	Spices, seeds (sesame, kalonji, etc.), bulgar, pistachios, dried fruits and other products	49	Not detected
ON restaurants	Fatoush salad ingredients, dressings and various seeds used as garnish	13	Not detected
ON retail samples	Rot, cookies, various seeds, tahini, spices and other retail food products	27	Not detected
Tested by the Alberta provincial laboratories			
AB case homes	Tahini, chicken breasts, kishk and various spices	21	Not detected
AB retail samples	Halva, pistachios, raw Halal beef and spices	5	Not detected
Tested by the Canadian Food Inspection Agency			
ON retail samples	Seeds (sesame, kalonji, etc.) and tahini products	40	Not detected in 39 samples *S.* Meleagridis identified in a kalonji whole seeds sample
AB retail samples	Seeds (sesame, kalonji, etc.), bakery and tahini products, spices and pistachios	63	Not detected in 62 samples *S.* Ruiru identified in a tahini sauce sample

Traceback

No convergence was identified in the supplier and distributor information collected from Ontario and Alberta food premises. Other than major suppliers, no commonalities were noted between the suppliers of the ethnic bakeries identified by cases in Ontario and Alberta.

Discussion

Outbreaks of S. Reading are not common. Previously documented S. Reading outbreaks have been associated with sprouts (7,8), iceberg lettuce (9), beef (10-13), pork (13), turkey (14,15), oysters (16), shepherd dogs (17) and an unknown source (18). Despite extensive epidemiological, microbiological and traceback investigations, a common source was not identified in this investigation.

This investigation adds to the literature exploring cultural factors (including barriers) related to outbreak investigation and control (19,20). It illustrates the importance of cultural competence, i.e. "the knowledge, skills and attitudes [...] that are necessary for providing health information, education and services among diverse groups" (4), for effective public health practice and restates that communicable disease outbreak investigations are aided by a culturally competent approach (21,22). Multiple strategies were used to address the critical ethnocultural component of this investigation. Public health personnel, including field epidemiologists, encountered barriers to hypothesis generation due to a lack of reference data on food preferences of the affected ethnocultural communities. To overcome this barrier, the initial questionnaire was tailored towards food items thought to be frequently consumed by individuals of Eastern Mediterranean origin. Additional effort was then invested in a three day food consumption history survey. Interviews were conducted by an Arabic-speaking environmental health officer and/or in partnership with a facilitator known to local public health through established community networks. Cases and community respondents were interviewed in their homes or in familiar community settings to build trust and promote information sharing. Interviews conducted in homes also provided the opportunity to collect food samples.

While resource intensive, these approaches proved invaluable for mitigating language and cultural barriers and for informing the development of the outbreak questionnaire and re-interview tool. Interestingly, despite disparate geographies and different ethnocultural communities affected by the outbreak in Ontario and Alberta, investigators in both jurisdictions aimed for a culturally competent approach that resulted in similar information gathering. This suggests that similar approaches could be adapted to meet the needs of different ethnocultural communities involved in outbreak investigations.

CFIA and provincial laboratories involvement in this investigation was crucial given the number of food samples that were submitted and analyzed. A challenge with a protracted outbreak investigation is that retail samples tested throughout the investigation are unlikely to be representative of the produce that was available at the time of case exposure. Moreover, data detailing the exact date(s) and location(s) of purchase of food items of interest were not available from all cases or small retail premises, which limited the ability of the CFIA to conduct traceback investigations.

Finally, the importance of molecular sub-typing in outbreak investigations cannot be overemphasized. As in many other countries, outbreak investigations in Canada are supported by skilled experts at PulseNet Canada. The ability to conduct PFGE supports identification of geographically disparate clusters that would otherwise be undetected. Reading is a rare *Salmonella* serotype and isolates were sent to the National Microbiology Laboratory for serotyping confirmation or designation. Thus, challenges in the timeliness of case reporting were encountered. For example, the extended delays between case onset and confirmation of an outbreak case resulted in delayed case interviews and food sampling.

Conclusion

Despite extensive epidemiological, microbiological and traceback investigations, a common source for this S. Reading outbreak was not identified. The identification of specific foods was challenging due to investigators' initial lack of familiarity with frequently consumed food items among affected individuals of Eastern Mediterranean origin, potential language and cultural barriers to case interviews, as well as a lack of background data on expected food exposures in the outbreak population.

Given Canada's ethnic and cultural diversity, cultural competence in approaches to enteric outbreak investigations and food consumption surveys may be useful. Specifically, routine inclusion of questions about ethnicity and/or ethnic foods on hypothesis-generating questionnaires would be of value. Socio-demographic data (income, housing, ethnicity, etc.) are typically not collected by communicable disease outbreak investigators; however, when relevant to exposure data, the information becomes critical. Consideration should also be given to adjusting the food items questioned and terminology adapted to be conducive to the cultures/communities involved. Additional investigative methods following initial case interviews may be indicated. For example, population food consumption surveys in the affected community or in-person open-ended interviews. Addressing the current national reference data gaps on food consumption in ethnocultural minority groups is also needed.

The outbreak investigation team and/or its partners would benefit from cultural competence skills in outbreaks that have an ethnocultural component to identify and address potential barriers. This may involve considering relevant evidence from other areas of public health practice (e.g. health promotion) and/or partnering with local public health and their existing community networks to engage effectively with individuals and ethnocultural and linguistic groups. Appropriate and relevant training to promote cultural competence among Canadian public health professionals, particularly those involved in enteric outbreak investigation, would aid in the implementation of the recommendations.

Author contributions

FT - Project Administration, Conceptualisation, Methodology, Investigation, Writing (original draft and review & editing), LV - Project Administration, Conceptualisation, Methodology, Investigation, Writing (original draft and review & editing), MA - Conceptualisation, Methodology, Investigation, Writing (original draft and review & editing), YW - Investigation, Writing (review & editing), LM - Conceptualisation, Writing (review & editing), LT - Resources, Investigation, Writing (review & editing), AH - Supervision, Writing (review & editing).

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Conflict of interest

None.

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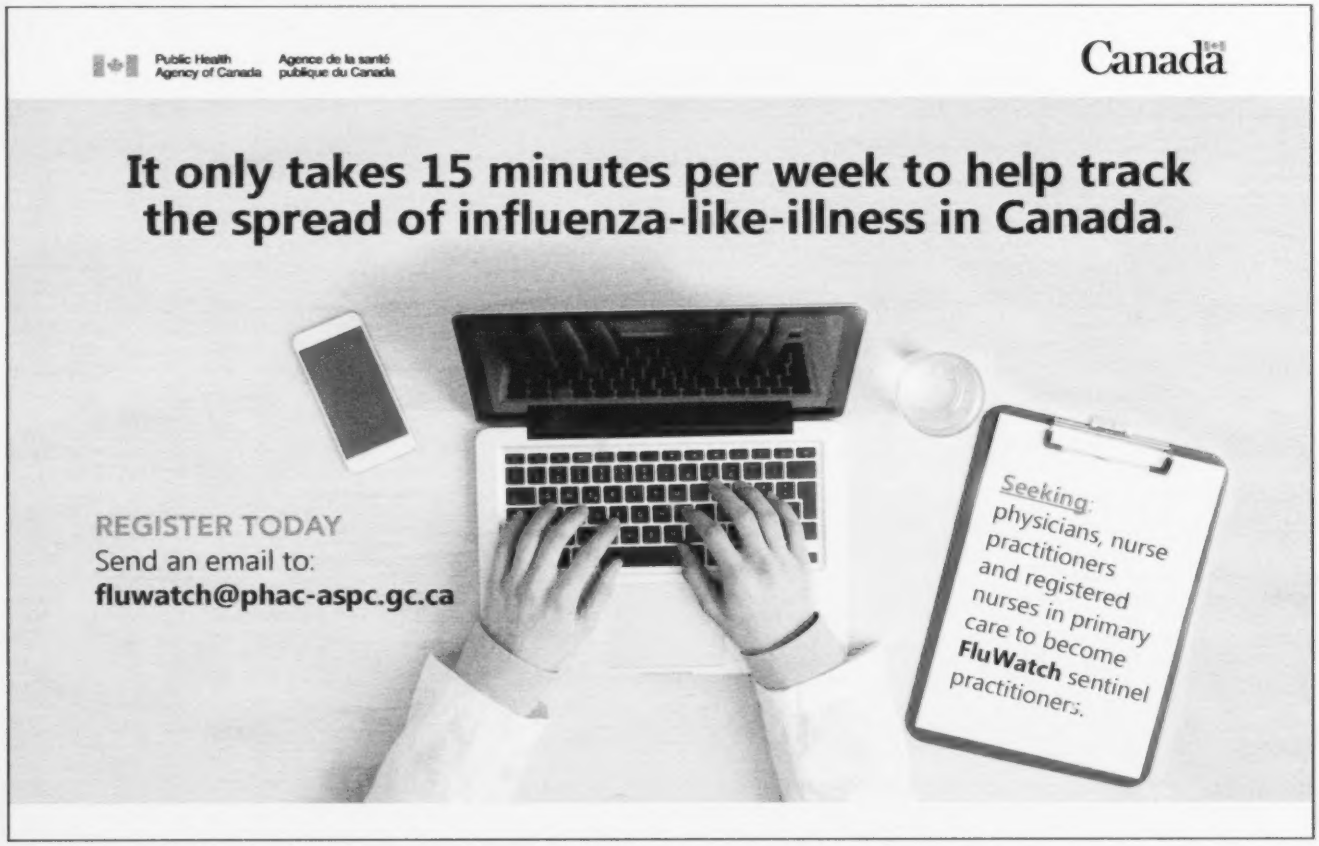
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Escherichia coli O157:H7 infections associated with contaminated pork products — Alberta, Canada, July–October 2014

L Honish[1,2*], N Punja[1,2], S Nunn[1,2], D Nelson[1,2], N Hislop[1,2], G Gosselin[1,2], N Stashko[2,3], D Dittrich[2,3]

Summary

What is already known about this topic?

Pork is a known, although infrequent, source of human *Escherichia coli* O157:H7 infection. *E. coli* O157:H7 infections often result in clinically severe illness with serious complications in humans.

What is added by this report?

During July–October 2014, an outbreak of 119 cases of E. coli O157:H7 infections associated with exposure to contaminated pork products occurred in Alberta, Canada. E. coli O157:H7–contaminated pork and pork production environments and mishandling of pork products were identified at all key points in the implicated pork distribution chain. Measures to control the outbreak included product recalls, destruction of pork products, temporary food facility closures, targeted interventions to mitigate improper pork-handling practices, and prosecution of a food facility operator.

What are the implications for public health practice?

Pork should be considered in public health E. coli O157:H7 investigations and prevention messaging, and pork handling and cooking practices should be carefully assessed during regulatory food facility inspections.

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† This paper is identical in content to the primary article published in the *Morbidity and Mortality Weekly Report (MMWR)* and released electronically on January 5, 2017, having met the guidelines for simultaneous publication as set forth by the International Committee of Medical Journal Editors (www.icmje.org)

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Introduction

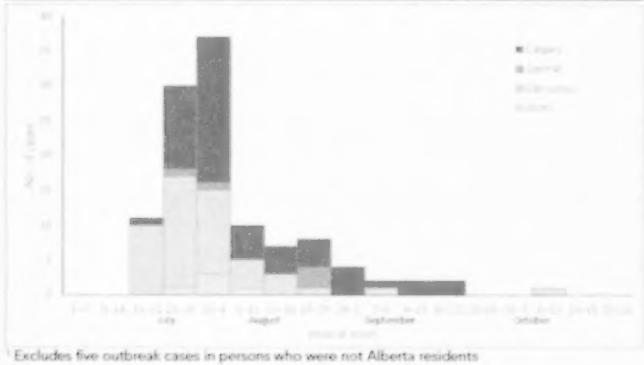
During July–October 2014, an outbreak of 119 *Escherichia coli* O157:H7 infections in Alberta, Canada was identified through notifiable disease surveillance and investigated by local, provincial, and federal public health and food regulatory agencies. Twenty-three (19%) patients were hospitalized, six of whom developed hemolytic uremic syndrome; no deaths were reported. Informed by case interviews, seven potential food sources were identified and investigated. The majority of patients reported having consumed meals containing pork at Asian-style restaurants in multiple geographically diverse Alberta cities during their exposure period. Traceback investigations revealed a complex pork production and distribution chain entirely within Alberta. *E. coli* O157:H7–contaminated pork and pork production environments and mishandling of pork products were identified at all key points in the chain, including slaughter, processor, retail, and restaurant facilities. An outbreak-specific pulsed-field gel electrophoresis (PFGE) cluster pattern was found in clinical and pork *E. coli* O157:H7 isolates. Measures to mitigate the risk for exposure and illness included pork product recalls, destruction of pork products, temporary food facility closures, targeted interventions to mitigate improper pork-handling practices identified at implicated food facilities, and prosecution of a food facility operator. Pork should be considered a potential source in *E. coli* O157:H7 investigations and prevention messaging, and pork handling and cooking practices should be carefully assessed during regulatory food facility inspections.

Epidemiologic Investigation

For this outbreak, a case was defined as a laboratory culture-confirmed *E. coli* O157:H7 infection with one of 16 PFGE cluster patterns identified in a resident of or visitor to Canada during July–October 2014. Cases were identified through notifiable disease surveillance.

A total of 119 outbreak cases were identified, including four (3%) in patients who were classified as having secondary infections (i.e., acquired through household contact with an outbreak-associated patient). All patients were in Alberta during all or part of the incubation period. Dates of illness onsets for the 119 patients ranged from July 20 to October 6 (**Figure 1**). Cases occurred among persons in a wide geographic distribution across Alberta. Twenty-three (19%) patients were hospitalized, six of whom developed hemolytic uremic syndrome; no deaths were reported. The median age of patients was 23 years (range = 1–82 years), and 76 patients (64%) were female.

Figure 1: Cases of pork-associated *E. coli* O157:H7 infection week of onset and region — Alberta, Canada, July–October 2014[1]



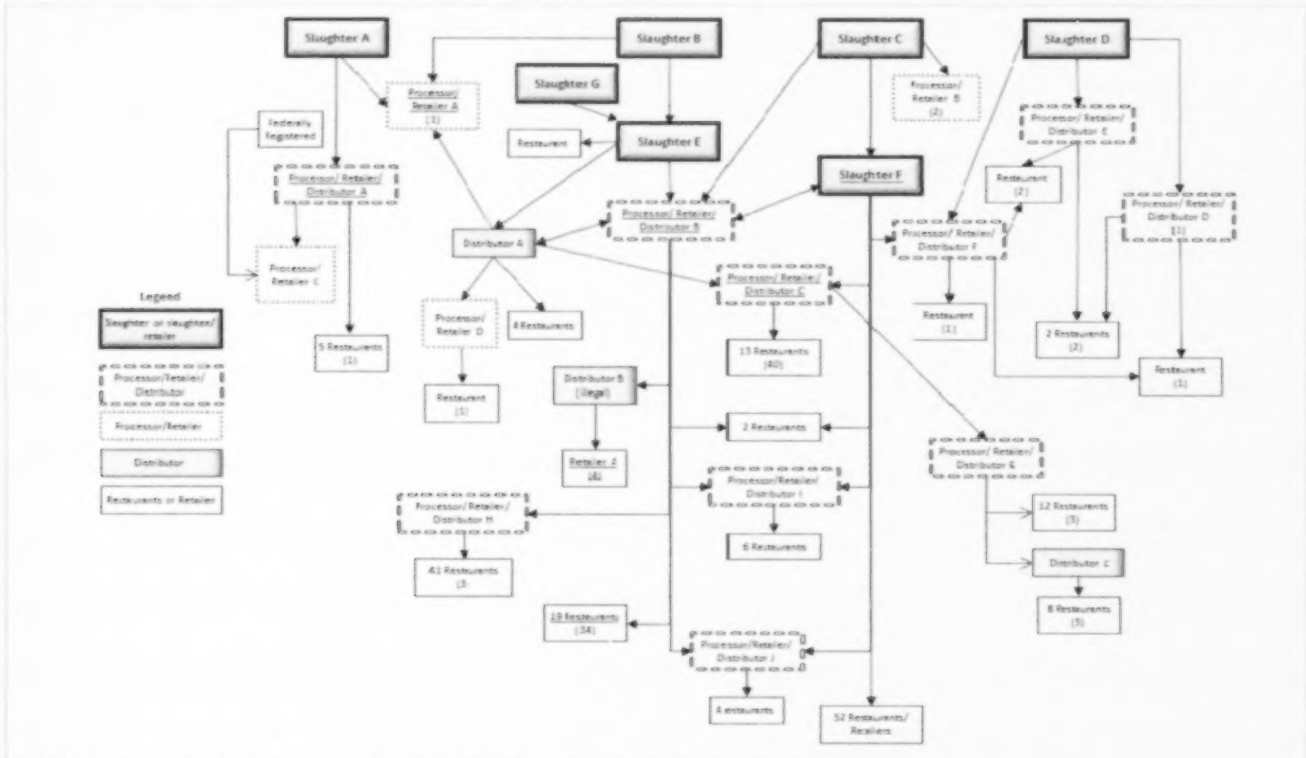
[1] Excludes five outbreak cases in persons who were not Alberta residents

Exposure to food at Alberta Asian-style restaurants (36 facilities widely distributed across the province) was reported by 85 (74%) of the 115 primary outbreak patients. Routine public health follow-up interviews failed to identify the source. Enhanced interviews with patients and follow-up at restaurants revealed that the exposure-specific frequency for each of seven ingredients (mung bean sprouts, beef, carrots, cucumbers, green onions, lettuce, and pork) exceeded 35%.

Environmental Investigation

Regulatory agencies conducted inspections at 201 restaurant and food processing facilities to inform the investigation and control the outbreak. Extensive investigation of Alberta mung bean sprout supplier/distributor facilities ruled out this product as a source. A traceback investigation was initiated that focused on suppliers of the six remaining high exposure-frequency foods. No single common restaurant supplier was identified for these foods. Pork was identified as the only ingredient with a supplier network entirely within Alberta, and thus emerged as the leading hypothesized source of the outbreak. Confirmation of the complex intra-Alberta pork supplier network (**Figure 2**) revealed

Figure 2: Alberta pork supplier network, pork-associated *E. Coli* O157:H7 outbreak — Alberta, Canada, July–October 2014[1,2,3,4]



[1] Underlined facility = *E. coli* O157:H7–positive sample collected from the facility directly or indirectly (i.e., at home of outbreak case)
[2] Numbers in brackets = number of outbreak cases with exposure to facility
[3] Some cases had multiple facility exposures
[4] Four secondary cases are excluded

that exposure to food from a facility within the network was the most common identified exposure (**Table 1**) among primary outbreak patients (96/115, 83%). Most of these exposures occurred at restaurants (81, 84%). Consumption of pork was identified among 65% of outbreak patients. A total of 295 samples, including environmental surface swabs (n=157), food (116), food surface swabs (13), and water (9), were collected and analyzed for the presence of *E. coli* O157:H7. Although a range of sample types were collected during hypothesis generation, sample collection later focused on pork and pork-production environments, as informed by the investigation. *E. coli* O157:H7 was identified in 18 samples,* all of which were from pork or pork products or surface swabs in pork production facilities. Apart from two isolates from a slaughter facility, PFGE cluster patterns identified in patient isolates matched those in food and environmental sample isolates. Four outbreak cases were associated with exposure to chicken sausage products from one facility; laboratory analysis of the products identified *E. coli* O157:H7, detected pork, and did not detect poultry. Investigation revealed that the chicken product producer had purchased pork fraudulently labeled as chicken by an illegal distributor linked to a facility in the Alberta pork-supplier network.

Table 1: Exposure characteristics of 115[1] primary cases of pork-associated *E. coli* O157:H7 — Alberta, Canada, July–November, 2014

Potential exposure sites	No. of patients with exposure to site	No. of patients with exposure to pork (%)
Asian-style restaurant(s)[2]	81	48 (59)
Asian-style market[2]	3	1 (33)
Sausage producer/ retailer[2]	4	4 (100)
Festival temporary food facility[2]	7	7 (100)
Meat processor/ retailer[2]	1	1 (100)
Asian-style restaurant(s)[3]	4	4 (100)
No suspect source facility[4]	12	10 (83)
Poor historian	3	N/A
Total	**115**	**75 (65)**

Abbreviations: N/A, not applicable; No., Number; %, percentage
[1] Four secondary cases excluded
[2] Facility within implicated pork supplier chain (96/115 primary cases had this exposure)
[3] Facility outside implicated pork supplier chain
[4] After complete exposure assessment

* Eighteen *E. coli* O157:H7–positive samples were obtained from the pork production environment (n=1); pork production equipment (5); pork carcass (1); raw fresh pork (4); raw frozen pork (1); raw marinated pork (3); spring rolls containing raw pork (1); chicken sausage containing raw pork (1); and a delivery vehicle (1) among one slaughter facility (facility F), two processing/distribution facilities (facilities B and C), one restaurant, and two private dwellings.

Public Health Response

The local health department ordered four facilities, including one slaughter/retail facility, two processor/distributor/retail facilities, and one restaurant facility, to temporarily close because of the numbers of cases associated with exposure to food distributed by the facility, critical food handling violations identified, or *E. coli* O157:H7–positive surface swabs. The illegal pork distributor fraudulently selling pork as chicken was issued court orders to close the business and to appear for questioning. The operator failed to appear, and an arrest warrant was issued. The Canadian Food Inspection Agency issued recall notices for pork products (and chicken products containing pork) distributed by six facilities. Multiple news releases issued to local media outlets informed the public of the outbreak investigation.

Root cause analyses were conducted by food regulatory agencies at four slaughter facilities implicated in the pork supplier network. All facilities slaughtered multiple species, including cattle. Common observations included opportunities for cross-contamination related to sharing of animal pens, inadequate cleaning and sanitation of knives or equipment between carcasses, and close proximity of carcasses during slaughter activities. At the slaughter facility that was temporarily closed, inconsistent personnel hygiene practices and poor knowledge of food safety were also identified. Corrective actions related to sanitary dressing procedures, process flow, hygiene, handwashing, cleaning, and sanitation were initiated and monitored through routine inspections. Products suspected of being contaminated were removed from one facility.

Environmental Health Officers (EHOs) with the local health department conducted comprehensive assessments of pork-handling practices and other potential contributing factors at 111 restaurants (those at which patients were thought to have acquired their infection and additional, selected similar restaurants in Alberta). EHOs observed practices used by operators at baseline, surveyed them about their procedures using a standardized questionnaire, and used this information to inform intervention strategies. Only 32% of operators used validated or standardized procedures for cooking pork products; 77% used visual indicators to ascertain whether pork products were adequately cooked. Cross-contamination concerns that might have contributed to infection were identified in several restaurants; for example, 74% of facilities did not use a cleaning schedule for food equipment, and food handlers did not wash their hands between tasks in 54% of facilities. At facilities that met food safety training requirements (82%), trained personnel often did not have direct oversight of day-to-day food handling activities. Interventions and ongoing monitoring programs with short, intermediate, and long-term objectives were implemented at the facilities to mitigate identified problems. This phased approach included delivery of onsite food safety training by EHOs, development and distribution of educational resources in the first language of employees (printed and online), and assistance with the creation of food safety plans for properly cooking pork products. Mitigation strategies included the distribution of digital thermometers and digital timers by EHOs. During onsite training sessions, EHOs demonstrated proper handwashing and environmental surface sanitation procedures and identified other strategies operators could use to reduce the likelihood of cross-contamination. Compliance with these food safety elements was measured before and after mitigation

strategies were carried out to help evaluate selected intervention measures.

Discussion

This outbreak represents the second largest foodborne and third largest overall *E. coli* O157:H7 outbreak in Canadian history, after a foodborne outbreak associated with salami produced in British Columbia in 1999 with 143 laboratory-confirmed cases (1) and a waterborne outbreak in Walkerton, Ontario in 2000 with 167 laboratory-confirmed cases (2). Strong epidemiologic evidence exists indicating that the cause of this outbreak was exposure to contaminated pork products produced and distributed in Alberta. The molecular epidemiology of the clinical and pork *E. coli* O157:H7 outbreak isolates is described elsewhere (3). Pork is a known, although infrequent, source of human *E. coli* O157 infection (4–8). Most documented outbreaks have been associated with sausage products containing pork and other meats, and the species-specific source of contamination was not confirmed. It has been reported that *E. coli* O157:H7 is prevalent globally at varying rates in swine, that infected swine might shed the bacteria for 2 months, and that horizontal transmission between swine and other livestock species might occur (9).

E. coli O157:H7–contaminated pork and pork production environments and mishandling of pork products were identified at all key points in the implicated Alberta pork distribution chain, including slaughter, processor, retail, and restaurant facilities. However, the originating source or sources of the contamination were not identified. Cross-contamination appears to be an important contributing factor in this outbreak, as evidenced by absence of known pork exposure in 35% of outbreak cases. On the basis of the findings of this investigation, pork should be considered a potential source in public health *E. coli* O157:H7 investigations and prevention messaging, and pork handling and cooking practices should be carefully assessed during regulatory food facility inspections.

Acknowledgments

Brent Friesen, Kate Snedeker, Adrienne MacDonald, Alberta Health Services; Linda Chui, Jocelyne Kakulphimp, Alberta Provincial Laboratory for Public Health.

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RAPID COMMUNICATION

Interim laboratory testing guidelines for the detection of non-tuberculous Mycobacterium (NTM) infections in post-operative patients exposed to heater-cooler units

K Antonation (Federal Co-Chair)[1], S Patel (Provincial Co-Chair)[2], J Trumble Waddell[1], P Guillaume Poliquin[1], DC Alexander[3], L Hoang[4], D Farrell[5], R Garceau[6], D Haldane[7], F Jamieson[2], R Marchand[8], A MacKeen[9], D Marcino[9]*, S Theriault[1], GJ Tyrrell[10], G Zahariadis[11], N Zelyas[10] on behalf of the Canadian Public Health Laboratory Network

Abstract

The advice contained in this document should be read in conjunction with relevant federal, provincial, territorial and local legislation, regulations, and policies. Recommended measures should not be regarded as rigid standards, but principles and recommendations to inform the development of guidance.

This advice is based on currently available scientific evidence and adopts a precautionary approach where the evidence is lacking or inconclusive. It was approved for publication on December 5, 2016. It is subject to review and change as new information becomes available.

The main changes to this version include additions to: Case load reported to date, Sarcoidosis-like disease as an Indicator, Whole Genome Sequencing effort, links to Provincial and Territorial Lab Services and Health Canada reporting.

Suggested citation: Antonation K (Federal Co-Chair), Patel S (Provincial Co-Chair), Trumble Waddell J, Guillaume Poliquin P, Alexander DC et al. Interim laboratory testing guidelines for the detection of non-tuberculous Mycobacterium (NTM) infections in post-operative patients exposed to heater-cooler units. Can Commun Dis Rep. 2016;43(1):25-8.

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Scope

This document outlines laboratory testing criteria and specimens to be collected for symptomatic persons with history of exposure to heater-cooler units during cardiothoracic heart surgery performed from November 1st, 2011 onward.

Background

A recent outbreak of *Mycobacterium chimaera* has been detected globally in patients who have undergone cardiothoracic heart surgery while in the presence of contaminated heater-cooler units. At this point in time, 52 cases of non-tuberculosis Mycobacterium (NTM) have been detected in Europe, and 2 within Canada (11).

There are many areas of uncertainty with respect to: 1) the magnitude and factors affecting infection risk, 2) clinical presentations of disease and 3) ideal management of devices.

At this time the risk to patients is thought to be low as evidenced by small number of cases reported globally. Risk estimates will be supplied as more information becomes available.

The Canadian Public Health Laboratory Network and its partners are working to support the laboratory response through the production of these *interim* recommendations.

This guidance document will focus on 1) defining patients at risk to establish criteria for testing and 2) recommendations related to the sample collection and testing for detection of *M. chimaera* in patients.

Clinical presentations* associated with post-operative non-tuberculous Mycobacterium infection

The majority of patients present three months to five years (median 18 months) after the index surgery, with symptoms of fever, fatigue, shortness of breath, night sweats, joint or muscle pain and unexplained weight loss (1,3,7). Cardiac manifestations include prosthetic valve endocarditis (PVE), prosthetic vascular graft infection (PVGI), paravalvular abscess, and pseudo and mycotic aneurysms (7.10). Extracardiac manifestations include bone infection (osteomyelitis, spondylodiscitis), sternotomy wound infection, mediastinitis, hepatitis, and bloodstream infection (BSI) (3,7,10). Ocular manifestations due to emboli (panuveitis, multifocal chorioiditis, chorioretinitis) are observed in approximately 50% of patients (3). Immunologic manifestations include arthritis, cerebral vasculitis, pneumonitis, myocarditis, granulomatous nephritis) (7,10). Splenomegaly is observed in approximately 80% of cases (3) as well as bone marrow involvement with cytopenia. Recent recommendations have raised awareness for granulomatous diseases, particularly those that resemble sarcoidosis (11). There have been case reports of *M. chimaera* patients who were initially diagnosed with sarcoidosis.

Patient testing criteria

Criteria 1: Risk exposure

Patients must have had cardiothoracicsurgery in the past. Due to the prolonged incubation time, patients who have had surgery from November of 2011 onward would be considered to meet this criterion.

Caveat: Some isolated reports involve patients without cardiothoracic surgery, but in a room with an active heater-cooler unit on standby. While these patients are not routinely felt to be at risk, such patients could be considered for NTM testing if a compatible clinical syndrome was present (see below).

Criteria 2: Compatible clinical syndrome

Overall patients tend to present with non-specific symptoms, making the distinction of NTM infection from other, more common causes of these symptoms difficult. To that end, a compatible syndrome is defined as presence of:

- **Constitutional**: recurrent or prolonged fever, fatigue, shortness of breath, weight loss, night sweats, joint or muscle pain
- **Cardiac**: prosthetic valve endocarditis and/or prosthetic vascular graft infection
- **Extracardiac**: bone infection, sternotomy surgical wound infection, mediastinitis, hepatitis, bloodstream infection, ocular infection (panuveitis, multifocal chorioiditis, chorioretinitis)
- **Immunologic/embolic**: splenomegaly, cytopenia
- **Infants**: febrile episodes and failure to thrive

Symptoms must have either: 1) appeared post-surgery or, 2) if present prior to surgery, must have significantly worsened following surgery AND symptoms should have been present ≥ three weeks. Persistence of these non-specific symptoms beyond three weeks helps to eliminate other infections that generally are diagnosed or resolved within that time span. In the absence of a diagnosis (both infectious and non-infectious) patients with unexplained symptoms should be investigated for possible *M. chimaera* infection.

Important testing considerations

- Asymptomatic individuals who have undergone cardiothoracic surgery should not undergo testing for M. chimaera, based on current evidence.
- It may be impractical to wait ≥3 weeks, either due to severe illness or when patient follow-up will be complex due to frailty or geographic access. Under these exceptional circumstances, one can consider proceeding to NTM testing without waiting.

Specimens

The following specimens should be submitted for mycobacterial cultures from eligible patients, as identified by the testing recommendations:

Clinical samples from sterile sites (**Table 1**), such as, but not restricted to, blood, purulent drainage, or fresh tissue should be sent for mycobacterial culture and acid fast bacilli (AFB) smear with accompanying requisition (**Appendix 1**: Links to local laboratory services). Please note, *M. chimaera* is a slow growing organism and detection through culture can take up to 6-8 weeks incubation. If it is early in the infection, *M. chimaera* may not be detected.

Positive cultures identified as *M. avium-intracellulare* complex microorganisms must be sent forward to a reference laboratory for 16S (or alternative such as hsp65/ITS) gene sequencing to confirm as *Mycobacterium chimaera* species at https://cnphi.canada.ca/gts/reference-diagnostic-test/5054?labId=1004. Sending pure culture on solid or in a liquid (minimum 4mL) medium is optimal for the reference laboratory.

Isolates potentially tied to this outbreak are currently undergoing whole genome sequencing as part of a national collaborative effort. Results are pending.

* Prior presentations: Published literature from Germany (5 cases)[1], Switzerland (6 cases)[1] and the United Kingdom (17 cases)[1] demonstrate that the majority of patients presented with endocarditis, paravalvular abscess, site infection or bacteremia associated with artery bypass graft, valve replacement or repair. Common accompanying signs and symptoms were fatigue, fever, hepatitis, renal insufficiency, splenomegaly and pancytopenia.

Table 1: Clinical testing for identifying potential cases of non-tuberculous Mycobacterium (NTM) following cardiac surgery

Clinical symptoms/ exposure	Specimen and testing recommendations
Asymptomatic **AND** Cardiothoracic surgery after Nov 1, 2011	None
Symptomatic[1] • Constitutional: recurrent or prolonged fever, fatigue, shortness of breath, weight loss, night sweats • Cardiac: prosthetic valve endocarditis and/or prosthetic vascular graft infection • Extracardiac: bone infection, sternotomy surgical wound infection, mediastinitis, hepatitis, bloodstream infection, ocular infection (panuveitis, multifocal chorioiditis, chorioretinitis) • Immunologic/embolic: splenomegaly, cytopenia • Infants: febrile episodes and failure to thrive **AND** • Open-chest surgery 3 months to 5 years prior to illness onset	• Blood: Request mycobacterial blood culture at local, commercial or reference laboratory as available (Appendix 1) - Specific incremental yield of multiple blood cultures is not known at present. A set of 2 cultures collected 12 hours apart is a reasonable option with more specific recommendations to follow as data becomes available. NTM isolation from a sterile site is highly likely to be clinically significant (12) • Tissue (including bone), and fluid: Request mycobacterial culture and acid fast staining at local, commercial or reference laboratory as available - Aseptically collect and submit in sterile container without fixative • Submit to laboratory with appropriate requisition indicating patient history • Refer culture to reference laboratory as necessary for species level discrimination

[1] Symptomatic is defined as: **Investigation of NTM infection in patients with prolonged illness (≥3 weeks) AND absence of alternative diagnosis through routine investigation to eliminate common etiologic agents**

Testing of heater-cooler units and surrounding environment

The authority to advise on the testing of heater-cooler units resides with Health Canada (http://healthycanadians.gc.ca/recall-alert-rappel-avis/hc-sc/2016/60662a-eng.php#issue-problem).

Reporting of adverse events from medical devices

Health Canada encourages healthcare professionals to report any cases of patient infection thought to be associated with the use of devices. The Medical Devices Problem Report Form and Guidelines (http://www.hc-sc.gc.ca/dhp-mps/compli-conform/info-prod/md-im/index-eng.php) can be found on the Health Canada Web site.

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Conflicts of interest

None

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Appendix 1: Link to provincial laboratory services

	Link to Laboratory Services	Laboratory Contact(s)
British Columbia	http://www.bccdc.ca/health-professionals/professional-resources/laboratory-services	mel.krajden@bccdc.ca
		mabel.rodrigues@bccdc.ca
Alberta	http://www.provlab.ab.ca/guide-to-services.pdf	greg.tyrrell@albertahealthservices.ca
		cary.shandro@albertahealthservices.ca
Saskatchewan	http://sdcl-testviewer.ehealthsask.ca/	paul.levett@health.gov.sk.ca
		dfarrell@health.gov.sk.ca
Manitoba	http://dsmanitoba.ca/	arendina@dsmanitoba.ca
		dswidinsky@dsmanitoba.ca
Ontario	http://www.publichealthontario.ca/en/ServicesAndTools/LaboratoryServices/Pages/Index.aspx	frances.jamieson@oahpp.ca
		kevin.may@oahpp.ca
Quebec	https://www.inspq.qc.ca/lspq/repertoire-des-analyses	hafid.soualhine@inspq.qc.ca
Newfoundland	www.publichealthlab.ca.	kessica.kafka@easternhealth.ca
		robert.needle@easternhealth.ca
Nova Scotia	http://www.cdha.nshealth.ca/pathology-laboratory-medicine/laboratory-client-support-center	david.haldane@nshealth.ca
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Information for authors: 2017

Introduction

The *Canada Communicable Disease Report* (CCDR) is a bilingual, peer-reviewed, open-access, online scientific journal published by the Public Health Agency of Canada (the Agency). It will soon be available in full text on PubMed Central. The CCDR provides practical and authoritative information on infectious diseases to clinicians, public health professionals, researchers, teachers, students and others who are interested in infectious diseases. The CCDR is published on the first Thursday of every month. In 2017 there will be joint issues published in March/April and July/August.

The CCDR welcomes submissions from across Canada and elsewhere of manuscripts that include practical, authoritative information on infectious diseases to inform communicable disease policy, program development and practice. The CCDR follows the recommendations of the International Committee of Medical Journal Editors[1] (ICMJE), Canada's Tri-Council Policy Statement on Ethical Conduct on Research Involving Humans[2], the Canadian Council of Animal Care Guidelines[3], the Council of Scientific Editors' Scientific Style and Format[4], the Treasury Board of Canada Secretariat's Policy on Official Languages[5] and Standard on Web Accessibility[6] and the Agency's Policy for the Publication of Scientific and Research Findings. The CCDR does not contain policy statements, except in summaries of advisory committee statements. Authors retain the responsibility for the content of their articles and opinions expressed are not necessarily those of the Agency.

Types of articles

Table 1 identifies the types of articles commonly published in the CCDR. Word counts cover the main body of the text and do not include the abstract, tables or references. Checklists for many article types have now been published. (See links in table.)

Table 1: The types of articles published in CCDR (in alphabetical order)

Type of article (word count)	Description
Commentary (1,000-1,500 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-04/surv-5-eng.php	Addresses a stand-alone issue, setting forth both strengths and arguments to support a point of view as well as outlining potential weaknesses and counter-arguments.
Epidemiologic study (1,500-2,000 words)	Includes cohort and case-control studies on infectious diseases as per the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE, http://STROBE) guidelines.
Implementation science (1,500-2,000 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/16vol42/dr-rm42-9/assets/pdf/16vol42_9-ar-01-eng.pdf	Describes an innovative process, policy or program designed to monitor or decrease the impact of an infectious disease and generally includes an evaluation of how it worked.
Invited editorial (1,000-1,500 words)	Comments on one or more articles published in the same issue, often placing it/them into a broader context.
Notes from the field (1,000–1,500 words)	Provides a first-hand practice-based account and insights about the prevention, detection or management of infectious disease.
Outbreak report (2,000-2,500 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-04/surv-2-eng.php	Provides information on an outbreak, summarizing its epidemiology, risk factors, associated morbidity and mortality, public health interventions, and outcomes.
Overview (1,500-2,000 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/16vol42/dr-rm42-9/assets/pdf/16vol42_9-ar-03-eng.pdf	Summarizes content from many specialized articles or sources into one broadly-scoped article, or introduces a topic for those who may be reading about issues outside their field of expertise.
Qualitative studies (2,000–2,500 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/16vol42/dr-rm42-9/assets/pdf/16vol42_9-ar-02-eng.pdf	Analyzes data from direct field observations, in-depth interviews and/or written documents to identify themes that generate hypotheses on complex phenomena.
Rapid communication (750-1,500 words)	Provides a short, timely and authoritative report of an emerging or re-emerging infectious disease that typically includes the results of preliminary investigations and any interim clinical and public health recommendations.
Report Summary (500-1,000 words)	Includes an abstract and a short summary of the Agency or Advisory Committee reports with links to the full report or statement.
Surveillance report (2,000-2,500 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-04/surv-3-eng.php	Summarizes the trends in the incidence or prevalence of an infectious disease in Canada.
Systematic review (2,000-2,500 words) http://www.phac-aspc.gc.ca/publicat/ccdr-rmtc/15vol41/dr-rm41-04/surv-3-eng.php	Provides a review of the literature on an infectious disease topic according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, http://www.bmj.com/content/339/bmj.b2700) guidelines.

The CCDR encourage submissions soon after a study is complete. Data should be no more than three years old.

1 http://www.icmje.org/recommendations/
2 http://www.pre.ethics.gc.ca/pdf/eng/tcps2-2014/TCPS_2_FINAL_Web.pdf
3 http://www.ccac.ca/en_/standards/guidelines
4 http://www.scientificstyleandformat.org/Home.html
5 http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=26160
6 http://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=23601#sec6.1

Other types of manuscripts may be appropriate. To assess potential suitability, consult the Editor-in-Chief (patricia.huston@phac-aspc.gc.ca) prior to submission.

Manuscript preparation and submission

Manuscript preparation

Manuscripts may be submitted in either English or French, and should be prepared with Microsoft Word (.docx). All author(s) and their primary affiliation(s) should be identified as well as the email address of the corresponding author. Research articles, include a 200- to 250-word structured abstract (Background, Objective, Methods, Results, and Conclusion). Commentaries and editorials should include a 150- to 200-word text abstract. Tables and figures should be sent as separate files. Figures must be created as editable files, such as Excel or PowerPoint, to permit formatting and translation. It is useful to review previous issues of the CCDR to check the formatting of tables and figures. For additional guidance, the ICMJE article "Recommendations for the conduct, reporting, editing and publication of scholarly work in medical journals" provides more detail on general manuscript preparation.

Authorship, contributorship and acknowledgements

All authors need to meet the four criteria for authorship[7] as set out by the ICMJE:

1. Substantial contributions to the conception or design of the work; or the acquisition, analysis or interpretation of data for the work; AND
2. Drafting the work or revising it critically for important intellectual content; AND
3. Final approval of the version to be published; AND
4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

The CCDR encourages the use of the "CRediT taxonomy". This taxonomy identifies all the contributions that can be made in the development of a manuscript so that the roles of authors and contributors can be identified based on this taxonomy (see **Table 2** below).

Authors are identified at the end of the manuscript by their initials and contributors are identified by their name. For example:

> Authors: AJ – Conceptualization, investigation, writing-original draft, review and editing; BJ – Methodology, software, validation, writing – review and editing.
>
> Contributors: John Smith – Supervision, resources, project administration.

Acknowledgements may also be noted. It is the responsibility of the corresponding author to ensure that anyone who is acknowledged has provided permission.

Table 2: The CRediT taxonomy*

Contribution	Definition
Conceptualization	Ideas; formulation or evolution of overarching research goals and aims.
Methodology	Development or design of methodology; creation of models.
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.
Validation	Verification, whether as a part of the activity or separate, of the overall replication/ reproducibility of results/experiments and other research outputs.
Formal analysis	Application of statistical, mathematical, computational or other formal techniques to analyze or synthesize study data.
Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.
Resources	Provision of study materials, reagents, patients, laboratory samples, animals, instrumentation, computing resources or other analysis tools.
Data collection and curation	Collection of data management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse.
Writing- original draft	Preparation, creation and/or presentation of the published work, specifically writing the initial draft (including substantive translation).
Writing – review and editing	Preparation, creation and/or presentation of the published work by those from the original research group, specifically critical review, commentary or revision.
Visualization	Preparation, creation and/or presentation of the published work, specifically visualization/ data presentation.
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.
Project administration	Management and coordination responsibility for the research activity planning and execution.
Funding acquisition	Acquisition of the financial support for the project leading to publication.

*Source: Brand A, Allen L, Altman M, Hlava M, Scott J. Beyond authorship: attribution, contribution, collaboration and credit. Learn Publ. [Internet] 2015 Apr [cited 2016 Dec 12];28(2):151–155. Available from: http://openscholar.mit.edu/sites/default/files/dept/files/lpub28-2_151-155.pdf.

7 http://www.icmje.org/recommendations/

8 http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html

Manuscript submission

Manuscripts should be submitted by email to: ccdr-rmtc@phac-aspc.gc.ca with a copy to the Editor-in-Chief (patricia.huston@phac-aspc.ca). Authors are invited to identify their ORCID[9] number.

Cover letter

When submitting a manuscript, a cover letter is sent that includes the following:

- A statement that the manuscript has not been published previously. (The CCDR generally considers only previously unpublished work.)
- An assurance that the manuscript has been reviewed and approved by all the authors and the ICMJE criteria for authorship[10] have been met.
- Attachments of a completed ICMJE Conflicts of Interest Form[11] from each author.

Prior to submission, authors employed by a government organization are responsible for obtaining approval or clearance that their manuscript may be submitted. Authors who work for the Agency require director-level approval for submission, in keeping with the Agency's Policy for the Publication of Scientific and Research Findings. It is an expected courtesy to copy those who have provided clearance in the cover letter.

The editorial and production process

Assessment and revision

Manuscripts that have been correctly submitted are screened by the editorial team for appropriateness and assessed with iThenticate[12] software for redundancy. Once a manuscript passes the initial evaluation, it undergoes a double-blind peer review process (reviewers do not know who the authors are; authors do not know who the reviewers are). Reviewers assess the manuscript for relevance, content and methodological quality, and identify what improvements might be made.

After analyzing the manuscript and considering the reviewers' comments, the Editor-in-Chief decides whether to request further revisions or declines the manuscript for publication. If revisions are indicated, an editor sends the reviewers' comments and any additional editorial comments to the corresponding author and invites them to revise the manuscript and provide a detailed response to each of the reviewer's comments. When the revised manuscript and response to comments are received, an associate editor and/or the Editor-in-Chief make the final decision whether to accept or decline the manuscript, or request additional revisions. The corresponding author is notified by email of the editorial decision.

The copyright of all papers published in the CCDR belongs to the Government of Canada. Therefore, once a manuscript is accepted for publication, authors are asked to transfer copyright. Authors who are outside the Government of Canada are required to sign a transfer of copyright agreement. For authors who are federal government employees, the copyright remains with the Government of Canada.

Production

All manuscripts accepted for publication are copy-edited, translated, desktop published and web-coded. Corresponding authors are sent a copy-edited version of their article to review for accuracy (the final quality control check) prior to web-coding; authors may also review the translated version upon request.

For further information

Contact the CCDR Editorial Office (ccdr-rmtc@phac-aspc.gc.ca) or the Editor-in-Chief (patricia.huston@phac-aspc.ca).

9 http://orcid.org/
10 http://www.icmje.org/recommendations/
11 http://www.icmje.org/conflicts-of-interest/
12 http://www.ithenticate.com

FluWatch Report: December 11 to December 17, 2016 (Week 50)

Source: Public Health Agency of Canada. Weekly influenza reports. FluWatch summary: December 11 to December 17, 2016. Available from: http://healthycanadians.gc.ca/publications/diseases-conditions-maladies-affections/fluwatch-2016-2017-50-surveillance-influenza/index-eng.php.

Seasonal influenza activity continues to increase in Canada.

A total of 692 positive influenza detections were reported in week 50. Influenza A(H3N2) continues to be the most common subtype detected.

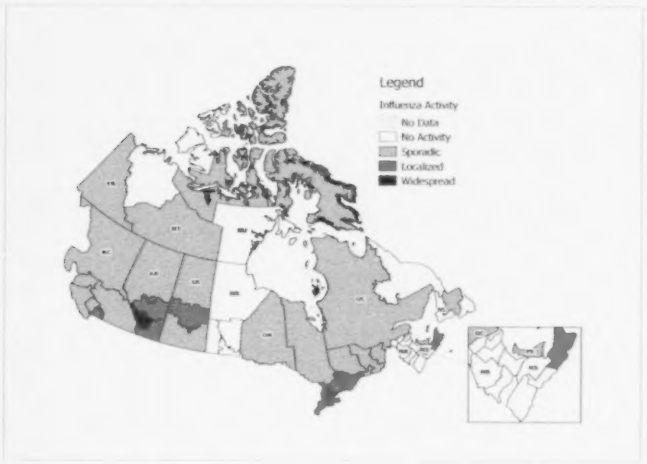
In week 50, 1.3% of visits to sentinel healthcare professionals were due to influenza-like symptoms.

Eighteen laboratory-confirmed influenza outbreaks were reported with the majority in long-term care facilities.

There were 98 influenza-associated hospitalizations reported from participating provinces and territories; 54 (56%) were due to influenza A(H3N2).

In week 50, a total of 19 regions in Canada reported no influenza activity. Sporadic influenza activity was reported in 20 regions across 11 provinces and territories (BC, AB, SK, ON, NS, NB, PE, NF, NT, YT and NU). Localized activity was reported in eight regions across four provinces and territories (BC, AB, ON and NS).

Figure 1: Map of overall influenza/ILI activity level by province and territory, Canada, Week 50



Note: Influenza/ILI activity levels, as represented on this map, are assigned and reported by Provincial and Territorial Ministries of Health, based on laboratory confirmations, sentinel ILI rates and reported outbreaks. Please refer to detailed definitions at the end of the report. Maps from previous weeks, including any retrospective updates, are available in the mapping feature found in the Weekly Influenza Reports (http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/flu-grippe/surveillance/fluwatch-reports-rapports-surveillance-influenza-eng.php).

Human cases of West Nile virus in Canada, 2016

Source: Public Health Agency of Canada. Surveillance of West Nile virus. Available from: http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/surveillance-eng.php.

During the West Nile virus (WNv) season from mid-April to October, Canada conducts ongoing human case surveillance across the country. Monitoring West Nile virus nationally is a joint effort between the Government and its partners, including provincial and territorial ministries of health, First Nations authorities and blood supply agencies.

The Government relies on the provinces and territories to report the number of West Nile virus cases. To accurately reflect the annual occurrence of WNv cases in Canada, health professionals need to remain vigilant in diagnosing WNv, and reporting cases to their public health regional authorities. Case definitions can be accessed at: National Surveillance for West Nile virus (http://healthycanadians.gc.ca/diseases-conditions-maladies-affections/disease-maladie/west-nile-nil-occidental/surveillance-eng.php).

In 2016, there were a total of 100 cases reported as of November 12, 2016. These numbers may change slightly as provincial or territorial public health organizations can sometimes retroactively identify cases. Surveillance detects only a portion of West Nile virus cases in Canada; the true number is likely greater.

West Nile virus clinical cases in Canada, reported as of November 12, 2016

Province/Territory	Total number of clinical cases
Newfoundland and Labrador	0
Prince Edward Island	1
Nova Scotia	0
New Brunswick	1
Quebec	27
Ontario	46
Manitoba	21
Saskatchewan	0
Alberta	4
British Columbia	0
Yukon	0
North West Territories	0
Nunavut	0
CANADA	100

Overall, the number of cases remain relatively low, although there has been a gradual increase over the last three years.

Cases of West Nile virus reported annually, 2006 - 2016

Year	Number of human cases
2006	151
2007	2215
2008	36
2009	13
2010	5
2011	101
2012	428
2013	115
2014	21
2015	80
2016	100

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To promote and protect the health of Canadians through leadership, partnership, innovation and action in public health.

Public Health Agency of Canada

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